André Cordeiro Valério

The Impact of Uncertainty and Commodity Prices on Emerging Economies

Belo Horizonte

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Dissertação apresentada ao Centro de Desenvolvimento e Planejamento Regional da Universidade Federal de Minas Gerais, como requisito parcial à obtenção do título de Mestre em Economia.

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“Scientific knowledge is a body of statements of varying degrees of certainty – some most unsure, some nearly sure, none absolutely certain.”

Richard Feynman

Resumo

Esse trabalho estuda o impacto de choques de incerteza e de preços de *commodities* em cinco economias latino-americanas exportadoras líquidas de *commodities*: Brasil, Chile, Colômbia, México e Peru. As análises foram feitas através de Vetores Autoregressivos Estruturais Bayesianos (BSVAR) com restrições na estrutura recursiva. Um choque que reduz a incerteza da economia global eleva o preço de *commodities*. A reação das economias é quase similar à de um choque positivo em preço de *commodities*: redução no risco soberano, apreciação cambial, aumento do PIB. Contudo, o impacto inflacionário não necessariamente será o mesmo em ambos os choques. Choque puro nos preços das *commodities* gera inflação, apesar da apreciação cambial. Mas elevação no preço das *commodities* devido a reduções na incerteza sobre a economia global não gera impacto inflacionário relevante por causa do canal financeiro: há maior apreciação cambial devido à intensa queda no prêmio de risco soberano. Banqueiros centrais devem interpretar de forma adequada a origem das oscilações nos preços de *commodities* para que possam conduzir política monetária de forma consistente.

Palavras-chave: Choques internacionais; Incerteza; Preço de commodity; Política monetária; Economias emergentes; SVAR Bayesiano; Exogeneidade em bloco.

Abstract

This work analyzes how five Latin American economies (Brazil, Chile, Colombia, Mexico and Peru) are impacted by shocks in the world economy uncertainty and in commodity price. Analysis is based on Bayesian Structural Vector Autoregressions (BSVAR) with block exogeneity. A shock that reduces global uncertainty increases commodity price. The economies react almost as similar as in the case of a pure (positive) shock to commodity price: sovereign risk falls, exchange rate appreciates, and GDP increases. However, the inflationary impact is not necessarily the same. A pure commodity price shock generates inflation, despite the nominal exchange rate appreciation. But an increase in commodity price due to reduction in global uncertainty is not as inflationary because of the financial channel: the nominal exchange rate appreciation is more profound due to a more intense contraction in sovereign risk. Central bankers need to properly interpret the origin of oscillations in commodity price to conduct monetary policy appropriately.

Keywords: External shocks; Uncertainty; Commodity prices; Monetary policy; Emerging economy; Bayesian SVAR; Block exogeneity.

List of Figures

List of Tables

Contents

Introduction

How commodity prices shocks affect emerging economies? To what extent are uncertainty shocks important to business cycle fluctuations in these economies? And most importantly, what are the challenges that these shocks impose to policymakers in emerging markets? This work tries to address these questions by providing new pieces of evidences on business cycles fluctuations in emerging economies using data from five Latin American countries: Brazil, Chile, Colombia, Mexico and Peru, all net exporters of commodities. By estimating a Bayesian Structural Vector Autoregression with block recursion, the main channels through which such shocks are transmitted can be identified and empirical regularities emerges, showing how the economic responses distinguishes from those of developed countries.

Most of Latin American countries are net exporters of commodities, and the commodity sector represent a great share of GDP, which makes these countries highly dependent on their commodity exporting sector. In the last decade (2000), Latin American economies observed an economic boom coinciding with a positive cycle in the world price of commodities. In several occasions, inflationary pressures appeared, but in others not. It is therefore important to understand in more detail how oscillations in commodity price are channeled through these economies. More specifically, when should we expect inflationary pressures and when we should not. This understanding is essential for an appropriate response of monetary policy.

After the oil crisis of the 70's and 80's, advanced economies observed a sharp reduction in the volatility of business cycles fluctuations, which has been referred as "The Great Moderation". However, the financial crisis of 2007 has put an end in "The Great Moderation", and it has been observed an increase in volatility, especially in stock markets. Higher volatility implies that economic uncertainty has risen as well and this has prompted several studies to analyze how uncertainty shocks affects the real economy. At least since Keynes (1937), which proposed that investment is the most volatile component of aggregate demand, especially because it depend of the agents' evaluation of the future, it has been acknowledged that uncertainty has real impacts, although it did not exist good measures of uncertainty to reasonably evaluate its impacts. Bloom (2009) proposed that uncertainty would be well proxied by stock market volatility, which has also been considered by several studies.

I follow suit and also consider the stock market volatility (measured by VIX) as a measure of uncertainty. Given VIX measures the implied volatility of S&P 500 index options, I go further to consider it as a metric for world economy uncertainty. It is then expected that a rise in this measure of uncertainty would result in "flight to quality", with international capital leaving emerging countries, seeking safer harbors. As it will be laid out in section 1, the responses in advanced economies are not necessarily the same.

Given the main interest of the paper, which is to evaluate the impact of oscillations in commodity prices in emerging economies that are net exporter of commodities, it is extremely important to consider global uncertainty. The reason, as it will be shown, resides on the fact that commodity prices react to global uncertainty shocks. Being able to disentangle the source of this price variation becomes extreme relevant for policy makers, since the source of oscillation affects differently an economy. Although Kilian (2009) has made the argument for this distinction, considering the oil market, the literature has not yet considered both variables jointly in order to properly understand their impacts on the dynamic response of emerging economies.

The main results are that a rise in commodity prices has expansive effects throughout Latin American economies, increasing GDP and accelerating inflation. A reduction in economic uncertainty will increase commodity prices as well, however, the effects on these economies are much stronger, since this shock is also intensively transmitted through financial channels: country risk falls by a factor of 7.5 stronger when compared to a pure commodity shock, provoking similar difference in the nominal exchange rate appreciation. The impact on product and inflation will then be clearly different. It follows that monetary policy should react differently depending on the source of commodity price change.

I expand the baseline econometric model to verify if the responses would modify when controlling for interventions in the foreign exchange market. However, the variables' responses do not alter considerably from the baseline model. Nevertheless, it is worth mentioning that intervention was detected for all economies, with magnitude varying with the nature of the shock. This suggest that these economies follow an inflation targeting regime with two targets and two instruments, as pointed by Ostry, Ghosh e Chamon (2012).

The rest of the paper is structured as follows. Chapter 1 points some particularities of emerging economies as well as the main studies on its business fluctuations, considering the role of both uncertainty and commodity prices shocks. Chapter 2 explain the empirical strategy to disentangle the effects of these two shocks in Latin American economies. Chapter 3 presents the main results obtained and section 4 offers some final remarks on the matter.

1 What we know about emerging economies and their cyclical fluctuations

Emerging economies are considered to be more vulnerable to economic fluctuations. In fact, there are several empirical regularities that show that real business cycles in emerging economies are substantially different from developed countries. The latter have seen a significant reduction of output volatility from the mid-80's until the eclosion of the last financial crisis, in a period known as "The Great Moderation". Some scholars argue that this stability was caused by better economic policies, specially those focused in controlling inflation, with the adoption of Taylor Rule and a monetary policy more predictable.

To see how volatility differs among developed and emerging economies, table[1] 1 shows the standard deviation of output[2] *per capita* growth rate of selected emerging economies from 1950 until 2009, while table 2 shows the output *per capita* growth of select developed economies.

Table 1 – Standard deviation of growth rates of emerging economies

Period	Argentina	Brazil	Chile	Colombia	Mexico	Peru	Uruguay	Venezuela
1950-2009	0.052	0.037	0.049	0.021	0.034	0.05	0.054	0.054
1950-1986	0.046	0.038	0.055	0.018	0.033	0.04	0.054	0.046
1987-2009	0.062	0.029	0.031	0.025	0.033	0.064	0.054	0.067

Table 2 – Standard deviation of growth rates of developed economies

Period	Australia	Canada	New Zealand	Norway	Portugal	Spain	Sweden	Netherlands
1950-2009	0.019	0.023	0.030	0.017	0.034	0.031	0.021	0.021
1950-1986	0.021	0.023	0.034	0.015	0.037	0.034	0.018	0.023
1987-2009	0.015	0.021	0.023	0.017	0.028	0.023	0.024	0.016

It is clear from tables 1 and 2 that emerging economies display higher output growth volatility. If we split the data in two periods, one from 1950 to 1986 and other from 1987 until 2009, we can see that the volatility in output growth in emerging economies has not been declining as it is observed in the set of advanced economies. The volatility has actually increased in some emerging countries after 1986.

[1] The database used to construct the graphs in figures 1 to 4 was compiled by Robert J. Barro and Josef Ursua, which is available online at http://scholar.harvard.edu/barro/publications/barro-ursua-macroeconomic-data

[2] GDP growth was obtained by first transforming the GDP index into log, then taking the first difference.

Another difference in business cycles between these two group of countries can be seen in tables 3 and 4, where the standard deviation of private consumption *per capita* growth rate for both sets of countries is plotted. As can be inferred by the tables, consumption is significantly more volatile in emerging economies than in developed ones. Actually, in many of these less developed countries, the volatility of consumption is higher than the volatility of output, indicating that in emerging economies families are not able to properly use the financial system to smooth their consumption over time, suggesting a less developed financial system.

Table 3 – Standard deviation of consumption growth rate of emerging economies

Period	Argentina	Brazil	Chile	Colombia	Mexico	Peru	Venezuela
1950-2009	0.061	0.050	0.080	0.027	0.039	0.050	0.073
1950-1986	0.054	0.056	0.095	0.026	0.037	0.043	0.076
1987-2009	0.071	0.035	0.034	0.026	0.041	0.059	0.070

Table 4 – Standard deviation of consumption growth rate of developed economies

Period	Australia	Canada	New Zealand	Norway	Portugal	Spain	Sweden	Netherlands
1950-2009	0.021	0.019	0.037	0.023	0.034	0.039	0.023	0.025
1950-1986	0.024	0.020	0.044	0.023	0.037	0.043	0.024	0.028
1987-2009	0.014	0.015	0.021	0.022	0.028	0.028	0.022	0.017

Uribe e Schmitt-Grohé (2015) treat these regularities shown in tables 1 to 4 as facts and draw some statistical evidences to support them. They show that business cycles in rich countries are about half as volatile as business cycles in emerging or poor countries. Also, not only consumption volatility is greater in emerging economies, it is more volatile than output. Finally, government consumption is countercyclical in rich countries, but acyclical in emerging and poor countries.

Therefore, these differences in business cycles fluctuations in emerging economies imposes difficulties in modelling them, since the models need to account for these singularities. Several studies using the Real Business Cycle (henceforth RBC) methodology have tried to explain the dynamics of emerging economies. The seminal paper of Mendoza (1991) develops an RBC model for small open economies (henceforth SOE-RBC) which has been used extensively in the literature as a base model for this type of economy. The author develops an extension of the classical RBC framework to account for empirical regularities in small open economies, such as the positive correlation between savings and domestic investment and that the current account and the trade balance tend to move countercyclically. The model is used to explore the interaction of domestic physical capital and foreign assets as alternative vehicles for savings in an environment in which stochastic disturbances affect domestic productivity and the world's real interest rate.

The work by Calvo, Leiderman e Reinhart (1993) find evidences that capital inflows in emerging markets are heavily influenced by external factors, in particular worldwide measures of investor‘s fear, having relevant impact in the real exchange rate and risk premium in these countries. As it will be shown, the uncertainty measure used here can be seen as investor‘s fear, therefore, their results suggests that this shock can impacted emerging economies through its effects on capital inflow.

Neumeyer e Perri (2005) extends the canonical SOE-RBC model with financial frictions to account for those empirical regularities cited above. One important aspect of their model is related to the nature of interest rate fluctuations. They assume that the interest rate faced by an emerging economy is the sum of two independent components, an international rate plus a country risk spread. Also, by assuming that firms have to pay for part of the factor of production before the production takes place, they create a channel through which the real interest rate can affect the level of economic activity. The authors model the interest rate by two means: one as a process completely independent from the fundamental shocks and other as a process that it is largely induced by these shocks. They find that the latter way can produce satisfactory results. Since the interest rate can affect the real activity through the necessity of working capital, interest rates fluctuations are induced by fundamental shocks but also amplify the effect of fundamental shocks on business cycles, contributing to high volatility. Using this model to evaluate the impact of interest rate fluctuations, they find that eliminating default risk in emerging economies can reduce about 27% of their output volatility, suggesting that country risk premium can have disturbing effects in these economies.

Uribe e Yue (2006) studies the role that interest rate plays in business cycles in emerging economies, specifically its relationship with country spreads. Since emerging-country spreads respond to changes in the world interest rate, it serves as a transmission mechanism of world interest rates, capable of amplifying or dampening the effect of the world interest rate shocks on the domestic economy. This occurs both because spreads depend on the world interest rate itself and because they respond to domestic fundamentals. Considering this, the authors conduct a two stage analysis. In the first stage a VAR is estimated to identify shocks to country spreads and the world interest rate, and to assess their impact on aggregate activity in emerging economies. In the second stage a standard model of the business cycle in small open economies is constructed to assess the plausibility of the identified shocks with theory. They find that country spreads play a significant role in propagating shocks, with US interest rate shocks explaining about 20% of movements in output. But most of this contribution is due to systematically response of country spreads to variations in this variable. If country spreads were independent of US interest rate, the role of US monetary shocks would be greatly reduced. Finally, the feedback from emerging-market fundamentals to country spreads significantly exacerbates business-cycle fluctuations.

The work by Garcia-Cicco, Pancrazi e Uribe (2010) criticize studies that do not consider the particularities of emerging economies in the modelling of RBC models. Many of previous studies did not find significant differences between business cycles in advanced economies and emerging economies, therefore, in emerging economies business cycles would be driven by permanent and/or transitory exogenous shifts in total factor productivity and transmitted through the familiar mechanism of the frictionless RBC model. For instance, the studies by Kydland e Zarazaga (2002) and Aguiar e Gopinath (2007) argues that the classical RBC model can satisfactorily replicate the fluctuations observed in emerging countries data. Garcia-Cicco, Pancrazi e Uribe (2010) challenge this view, arguing that these two studies do not consider a sufficient long time series, which generate this result and that the hypothesis underlying the traditional RBC models do not well represent the reality of these economies. The authors fit a classical RBC model to Argentine and Mexican data and discover that it performs quite poorly, having not been able to explain the movements observed in the variables in the data set. Subsequently, they estimate an augmented version of the RBC model that take into account financial frictions and fit it to Argentine data and it performs really well, predicting that permanent productivity shocks explain a negligible fraction of aggregate fluctuations, giving little support to the hypothesis that the cycle is the trend.

Hevia (2014) builds a standard small open economy model for Mexico and Canada to examine the fluctuations in emerging markets. As it should be expected, he finds evidence of different responses between emerging and developed economies. By decomposing fluctuations in Mexico and Canada in terms of reduced form shocks that drive a wedge between marginal rates of substitutions and marginal rates of transformation relative to a frictionless open economy, the author finds three reduced form shocks that explain aggregate fluctuation in Mexico, which are shocks to aggregate productivity, to labor markets and to the marginal rate of substitution between leisure and consumption, while in Canada only one shock explains the fluctuation, which is a shock to efficiency and labor wedges. The author reassure the necessity of a specific modelling for emerging economies, since the classical RBC model with just productivity shocks do not provide an accurate characterization of the fluctuations in these economies.

Another branch of the literature is interested in analyze the transmission of external shocks to small open economies. With greater economic and financial integration due to increase in globalization, these economies have become more likely to experience deep impacts from external events. Therefore, from the point of view of policy making, is relevant to understand possible channels of transmission of international shocks. We expect that external shocks will be mostly transmitted through international trade and financial markets. As Canova (2005) explains, the international trade channel would work as follows: supposing a commercial relation between a big open economy and an small open economy, a rise in the price level in the big economy will deteriorate the terms of trade for the small economy, increasing the prices of the imported goods relatively to the exported goods. Therefore, the net exports will be positively affected. Here, the exchange rate plays an important role in determining the pass-through to domestic inflation. The financial market channel would work as follows: supposing a rise in the interest rate of the big economy, the exchange rate of the other countries would have to depreciate. Again, the exchange rate plays an important role, because if it is fully flexible we will not observe any variation on macroeconomic aggregates. However, if this is not the case, a rise in the international interest rate will have real impacts. Additionally, the SOE-RBC literature stress that another important channel of transmission of international shocks, specially for emerging markets, are country risk premium, which are extremely dependent of international investors assessment of the current state of the world economy as well as the current state of the particular emerging economy. We would expect that a rise in country risk premium could be both because of high international uncertainty or poor performance of the local economy. As a result, the expected effects would be a shortage in external credit, occurring a "flight to quality" event, where international investors would redirect their investments to safer assets like U.S. treasury bonds.

Among the empirical works that tries to disentangle the effect of external shocks in these economies, some stand out. Cushman e Zha (1997) consider the challenges to correctly identify monetary policy under flexible exchange rates in small-open economies. Using data from Canada, they estimate a VAR that explicit imposes the assumption of small-open economy, which is done through block recursion, not allowing that international variables be affected by domestic variables. This assumption combined with the informational identifying structure used by Leeper, Sims e Zha (1996), solve all the recurrent puzzles encountered in works like this. Although they do not analyze external shocks explicitly, their methodology is very relevant to studies of small open economies, because block recursion makes the model more reasonable, assuming that the dynamics of an small open economy do not impact external variables.

The work by Arora e Cerisola (2000) evaluate the impact of U.S. monetary policy over emerging economies, giving special attention to the impact on country risks. The authors find evidences that U.S. monetary policy has direct positive effects on sovereign bonds spreads. However, if investors can anticipate in some degree the effects of the American monetary policy, the impact and contagion on developing countries can be mitigated.

Kim (2001) examines the international transmission mechanism of U.S. monetary policy shocks using VAR models for non U.S. G-7 countries. He finds evidences that an expansionary monetary shock leads to booms in the other countries and the main channel is the increase in world aggregate demand, through the world real interest rates. Also, a monetary expansion worsens the trade balance in the short-run, although improves it persistently in the medium and long-run. The countries choice may be not the most interesting to assess the impact of U.S. monetary shocks, since developed and industrialized countries have more resources to deal with the possible impacts, with better institutions and better policy design. Anyhow, the author finds evidences that these shocks matter even to these countries.

Canova (2005) studies the extent and how U.S. shocks are transmitted to several Latin American countries. Using a two-step approach to identify U.S. structural shocks, he finds evidences that fluctuations in emerging economies follow a different pattern from those documented in developed economies. The main results are that U.S. real demand and supply shocks has little relative importance and small impact on these economies. On the other hand, U.S. monetary shock induces large and significant responses, through the interest rate channel. In a typical Latin American economy, a rise in U.S. interest rate is immediately followed by a rise in the domestic interest rate, which creates a large differential in favor of Latin American, resulting in capital flows, improving reserves and local aggregate demand. Therefore, U.S. monetary disturbances are turned into good output news which is exacerbated by depreciation in the real effective exchange rate which induces a temporary improvement in the trade balance. However, the trade channel seems to play a negligible role. Additionally, U.S. disturbances account for an important portion of the variability in these economies, affecting policy making because there is evidence that just putting the house in order is not enough to avoid cyclical fluctuations. Therefore, policy makers should also pay attention to developments in the American economy.

Finally, Mackowiak (2007) examine the effects of U.S. monetary policy in a set of 8 emerging economies. Using a structural VAR with block exogeneity, he finds that the interest and exchange rate reacts quickly and strongly after an American monetary shock. However, U.S. monetary policy shocks are not important for emerging markets relative to other kinds of external shocks.

More recently, a new source of economic fluctuations has been brought into the spotlight. Several studies has been focusing in understanding the real effects of uncertainty shocks. At least since Keynes (1937), which proposed that investment is the most volatile component of aggregate demand specially because it depends of the agents' evaluation of the future, we know that uncertainty has real impacts, although it didn't exist a good measure of uncertainty to reasonably evaluate its impacts.

Bloom (2009) tries to fill that void in the literature. The author analyzes the real effects of uncertainty shocks, both empirically and theoretically. He develops a dynamic model that accounts for uncertainty and the main result is that the model yields a central region of inaction in hiring and investing. Therefore, firms will only invest when the conditions are good enough and only disinvest when the conditions are bad enough. Uncertainty has a central role in this region of inaction because when uncertainty increases, this region expand, since the option of wait and see becomes more valuable. Additionally, the author empirically tests the impact of uncertainty shocks in real variables. To do so, he proposes a measure of uncertainty, which is the Chicago Board of Options Exchange VIX index of percentage implied volatility, on a hypothetical at the money S&P100 option 30 days to expiration. Subsequently, a reduced form VAR is estimated and there are evidences that a rise in uncertainty decrease the industrial production for about 4 months, followed by recovery and rebound from 7 months after the shock. The impact is similar on unemployment.

Fernández-Villaverde et al. (2011) analyzes the real effects of changes in the volatility of the interest rate at which small open emerging economies borrow. They find evidences that volatility of the interest rate plays an important role in economic fluctuations of these countries, having substantial effect on output, consumption, investment and hours worked, and these effects appear even when the realized real interest rate itself remains constant, indicating that uncertainty about the future path of the real interest rate lead to changes in optimal choices by the economic agents. The authors expand the model presented by Mendoza (1991) with incomplete asset markets and stochastic volatility to model heteroskedastic shocks. The authors suggests that higher time-varying volatility may be one of the reasons why business cycles in emerging economies are different from those in small open developed economies. However, they do not see it as a candidate substitute for any other theory. Instead, they see it as a complement, making the several channels of transmission explored by the literature stronger in the presence of higher time-varying volatility.

Bekaert, Hoerova e Duca (2013) tries to account for the co-movement between the VIX index and the real interest rate. VIX is often used as a measure of risk aversion and uncertainty in the marketplace. However, to fully capture these characteristics, they decompose the VIX index in two components. Their objective is to analyze the effects of monetary policy on risk and uncertainty and vice-versa. To do so, they estimate an SVAR using a measure of monetary policy and business cycle fluctuations, in addition to the decomposed VIX index. They find that a lax monetary policy increases risk appetite in the future, with the effect lasting for more than two years. The impact on uncertainty is similar. Conversely, high uncertainty and high risk aversion lead to a laxer monetary policy in the near-term future. Therefore, there are evidences that the Fed uses monetary policy as a mean to calm financial markets. Also, there is evidence that investors take advantage of this to pursue high risks investments.

Christiano, Motto e Rostagno (2014) study the impact of risk shocks in the aggregate economy using a DSGE model. The main result is that risk shocks account for a large share of the fluctuations in GDP and other macroeconomic variables. Bloom et al. (2014) analyzes the role of uncertainty shocks on business cycles fluctuations. The authors gather evidence from both micro level data and from the broader effects of these shocks, using a DSGE model. The main result is that increased uncertainty makes it optimal to firms to wait, leading to significant falls in hiring, investment and output. Overall, these effects generate a rapid drop and rebound in GDP of around 2,5%. These results are in line with the literature about uncertainty shocks. Additionally, the authors estimate the effectiveness of economic policy in an environment of uncertainty. They find evidence that uncertainty lead to time-varying policy effectiveness, because the policy loses much of its power to impact the real economy when the economy is going through an uncertainty shock. Therefore, uncertainty shocks has a double effect in the economy, not only it directs impact real variables, it also affect indirectly by reducing the response of the economy to any potential reactive stabilization policy.

Baker, Bloom e Davis (2015) develops an economic policy uncertainty index relying on an extensive research on newspaper archives. To construct the index for the U.S. they rely on 10 leading newspapers and count the number of articles that contain a specific triple of words that present some uncertainty about economic policy making. To test the effectiveness of their index, the authors performed two econometric exercises and tries to draw observations about the effects of uncertainty in the real economy. Using firm-level data, they estimate several regressions that try to capture the exposure of these firms to a particular aspect of policy, considering their activity sector. They find that the sectors that depend heavily on government spending are the ones most affected by uncertainty regarding fiscal policy, having impact on investment and employment. To assess the impact of policy uncertainty on the aggregate economy, the authors estimate a VAR for the US and 12 other countries. An increase in policy uncertainty result in a decline of 6% in gross investment, 1.2% in industrial production and 0.35% in employment. The results are similar to the other countries which the index was constructed.

Among the papers that analyze the impact of uncertainty shocks in emerging economies, the are two that are more related to this present study. Carrière-Swallow e Céspedes (2013) examines if the impact of uncertainty shocks as presented by Bloom (2009) can be generalized to a broader group of emerging economies. The authors estimate a VAR for each country and discover that emerging economies react differently from industrialized countries to uncertainty shocks, being more severe to the former. Much of this variation in response to these shocks in emerging economies is due to the role of credit in the wake of an uncertainty shock. The authors conduct a counter-factual experiment in which they keep credit constant, in other words, they ask what would be the response of these emerging economies if the supply of credit was not affected at all by the uncertainty shock. By doing this they shut off the endogenous response of credit to the uncertainty shock and observe that emerging economies react similarly to the developed economies. This suggests that we observe a “flight to quality” event in response to uncertainty shocks in emerging economies, with international investors seeking safer assets, limiting the supply of credit and generating a more severe fall in investment and consumption.

Akıncı (2013) does not explicitly consider the effects of uncertainty in the way proposed by Bloom (2009). The latter analyze the impacts of second-moment order of financial shocks, while the former is more interested in the first-moment order. However, Akıncı (2013) uses a panel VAR to analyze to which extent global financial conditions can influence macroeconomic fluctuations in emerging economies. More specifically, the author considers a shock in a global risk-free interest rate, measured by U.S. interest rate, a global financial shock, measured by the U.S. corporate bond spreads, and a country spread shock. Country spreads play an important role in the model since it impact the ability of emerging economies to finance themselves. Also, the impact of global financial shocks in the aggregate economy will most likely be transmitted through country spreads. The author develops an empirical model that follows closely Uribe e Yue (2006) and the countries studied are chosen to closely match the ones studied by them. The main results indicate that global financial shocks have a large role in emerging economies business cycles, explaining about 20% of their fluctuation. Country spreads are also relevant, explaining about 15% and movements in country spreads are largely explained by global financial conditions. In a counterfactual exercise to disentangle the importance of country spreads fluctuations in transmitting such shocks, the author impose a restriction that country spreads do not react directly to variation in global financial risk. As a result, he finds that the variability of the main aggregates variables is largely reduced, indicating that country spreads are the main channel in which these shocks are transmitted to the real economy.

In theory, the effects of commodity prices shocks in commodity-exporting economies are well known. The literature highlight four effects: the external balance effect; the commodity currency effect; the spending effect; and the Dutch disease effect.

The external balance effect predicts that trade and current account balances are correlated with their terms of trade. In commodity-exporting economies, a rise in commodity prices will make the terms of trade favorable to them, increasing the revenue from exports and decreasing the risk perception of international investors, expanding credit and, consequently, the real activity, since the cost of borrowing in the foreign market is reduced. It will also lead to an increase in foreign assets or a reduction of foreign debt or both. The spending effect predicts that a share of the export income may be spent inside the economy, increasing aggregate demand. As pointed in the external balance effect, the reduction of risk perception of international investors will reinforce the spending effect as well, increasing credit for investment, for instance.

Commodity currency occur when a country's currency is strongly correlated with the price of their commodity exports. Chen e Rogoff (2003) estimates exchange rate models for Australia, Canada and New Zealand and find that the U.S. dollar price of their commodity exports has a strong correlation with their real exchange rates. Cashin, Céspedes e Sahay (2004) find evidences of long-run relationship between real exchange rates of commodity-exporting countries and the price of the commodity they export. Tashu (2015) investigates if the Peruvian currency is a commodity currency, but find that export commodity prices does not have statistically significant impact on Peru's real exchange rate. One of the reasons suggested by the author is foreign exchange intervention done by the central bank, which might have been successful to neutralize the impact of commodity prices shock in the real exchange rate. This will be investigated here, as it will be made clear in the next sections. The commodity currency effect implies that an increase in commodity prices would result in an appreciation of the real exchange rate, given the inflow of foreign capital. This effect might lead to the Dutch disease effect, which might be the most known and feared effect of increase in commodity prices. The appreciation in the real exchange rate will reduce the competitiveness of the non-commodity tradable sector of the economy, which may lead to deindustrialisation, turning the economy even more dependent on the commodity sector.

In addition to these four effects, a rise in commodity prices can generate a Balassa-Samuelson effect throughout the economy. Since the economies analyzed here are all net exporters of commodities and this product represent a considerable share of their GDP, the commodity sector will most likely be the most productive. An increase in commodity prices will redirect resources towards this sector, making it even more productive. The Balassa-Samuelson effect posits that an increase in productivity in the commodity sector will increase wages in this sector, which will generate an increase in wages in the non-tradable sector as well in order to equalize it throughout the economy, ultimately leading to increases in prices of the non-tradable sector. This dynamic will lead to an appreciation of the real exchange rate as well. This has an additional expansive effect in credit supply, because the value of banks' assets will rise as well, while their liabilities will remain at constant prices. This expand their net worth and allows banks to have additional funding from external sources, increasing the credit supply.

Empirical studies about the effect of commodity prices shocks are more common in the literature. However, many of these studies focus on oil price shocks and its effects on economies that are net importers of oil, like the United States. Many of these papers are motivated by the fact that many U.S. recessions were preceded by an increase in oil prices, and the evidence suggests that after an oil shock, the U.S. economy suffers a severe drop in economic activity. See for instance Hamilton (2003), Kilian (2008b), Kilian (2008c). Kilian (2008a) find evidences that oil shocks have very similar effects across the G-7 countries, decreasing real GDP growth and leading to inflation.

One common characteristic of studies which investigates the effects of oil prices shocks is that they implicitly consider that when the oil price varies, the rest of the variables is kept constant. Kilian (2009) challenges this approach, arguing that the price of oil, and of any other commodity, is driven by distinct demand and supply shocks. And since the price of commodities is set in the global market, global shocks will have important distinctive impacts in the economies, depending on the source of the shock, therefore, not all commodity prices shocks are alike. This explain why the U.S. economy has been more resilient to recent increases in the oil price, since the main driver behind its increase was global demand, which have expansive impact on the U.S. economy as well.

Charnavoki e Dolado (2014) estimates a structural dynamic factor model for Canada to investigate the effects of global shocks on commodity-exporting economies. Following Kilian (2009), the authors stress that commodity shocks must be dealt with caution, because not all commodity prices shocks are equal. They identify three different shocks that can drive real commodity prices: a global demand shock, a global commodity-specific shock and a global non-commodity supply shock. The results indicate that a global demand and a global commodity-specific shock play a more important role, explaining a large part of the volatility in real commodity prices. A global demand shock generates a significant expansion in global economic activity, increases global inflation and pushes up real commodity prices. A negative global supply shock leads to a decline in real activity, accelerates inflation and depresses real commodity prices. Lastly, a negative global commodity shock give rise to a temporary spike in global inflation and very strong increase in real commodity prices. Although all three shocks impact real commodity prices, the effects throughout the economy are not the same. When analyzing external balances and commodity currency effects, it does not matter the source of the shock, their reaction will be the same. However, the effects on aggregate expenditure are significantly different depending on the source of the shock.

The discussion of how monetary policy should react to commodity prices fluctuations is more focused in advanced countries and suggest central banks to only react to second round effects, which refer to the indirect impact on other prices, through cost or demand pressures. Advanced countries are commonly net importers of commodity, and the effects of prices fluctuations are more straightforward. However, these effects to emerging countries, which are commonly net exporters of commodity, are quite different and require different policy prescriptions.

Nevertheless, the argument done by Kilian (2009) is valid both for commodity net importer or commodity net exporter countries. Regarding the U.S. economy, Bodenstein, Guerrieri e Kilian (2012) estimate a two-bloc DSGE model that encompasses trade in oil and non-oil goods and endogenize oil prices fluctuations. They consider several structural shocks, all of them having impact on either demand for oil or supply of oil. Their findings suggest that there are no two structural shocks that induce the same monetary policy reaction, showing the importance on the source of the shock in order to monetary policy respond appropriately. Their results are in line with previous findings by Kilian (2009) and contradicts the popular notion that as long as the fluctuation in oil price is due to foreign factors, it should be considered just like an exogenous oil supply shock, from the point of view of other oil importers, as it is argued by Blanchard e Gali (2007). As can be seen, most of these studies focus on net importers of commodity and are mainly concerned with the impacts of commodity prices fluctuations in the American economy. Research is therefore needed to investigate the impacts of such shocks in emerging economies, which it is accomplished here, focusing specifically on countries that are net exporters of commodities. Depending on the relevance of these commodities for trade balance, a country may have a commodity currency, that is, its nominal exchange rate would be mostly determined by variations in the price of commodities they export. This pattern could potentially make variations in commodity prices non inflationary, given the compensation in their nominal exchange rate. Therefore, not every commodity prices fluctuation will have the same effect on commodity exporter emerging economy.

The works described here suggest that external shocks play an important role in emerging economies and one must be cautious of them to model these economies correctly. These findings will serve as guide to this work and I try to provide further evidences by investigating the effects of two shocks that normally are not analyzed together, which can be misleading. To do so, I estimate a Bayesian Vector Autoregression model, which is presented in the next section.

2 Empirical model

2.1 The dataset

In order to assess the importance of global uncertainty and commodity prices shocks to emerging economies I estimate the same model for five different Latin American countries: Brazil, Chile, Colombia, Mexico and Peru. These countries were chosen because they share some similarities. They are from the same region, therefore a possible geographical effect is controlled; they are net commodity exporters; and follow an inflation targeting regime at least since the 2000s.

In the international side, I use the all commodity price index, computed by the IMF. Global economic uncertainty is captured by the VIX index. Since the work of Bloom (2009), VIX has become an empirical standard as a proxy for uncertainty[1]. It is an index computed on a real-time basis throughout each trading day which measures the volatility of the stock market. Formally, the VIX is computed by the Chicago Board Options Exchange (CBOE) and quantify market expectations of near-term volatility conveyed by S&P 500 Index (SPX) option prices and represents expected *future* market volatility for the next 30 calendar days, therefore, it is important to emphasize that VIX is forward-looking measuring volatility that investors expect to see according to option price.

In his seminal work, Bloom (2009) uses the VXO index, which is similar to the VIX, but it is the implied volatility of the S&P 100 index, instead of the S&P 500. He argues that stock market volatility is a good proxy for uncertainty and show that it highly correlates with other measures of uncertainty. Figure 1, taken from Bloom (2009), plots stock market volatility which displays large bursts of uncertainty after major shocks, which temporarily double (implied) volatility on average and it can be seen that stock market volatility respond to uncertainty about future events, representing a good proxy for it.

[1] Whaley (2009) provides a detailed discussion about the origins and uses of the VIX index.

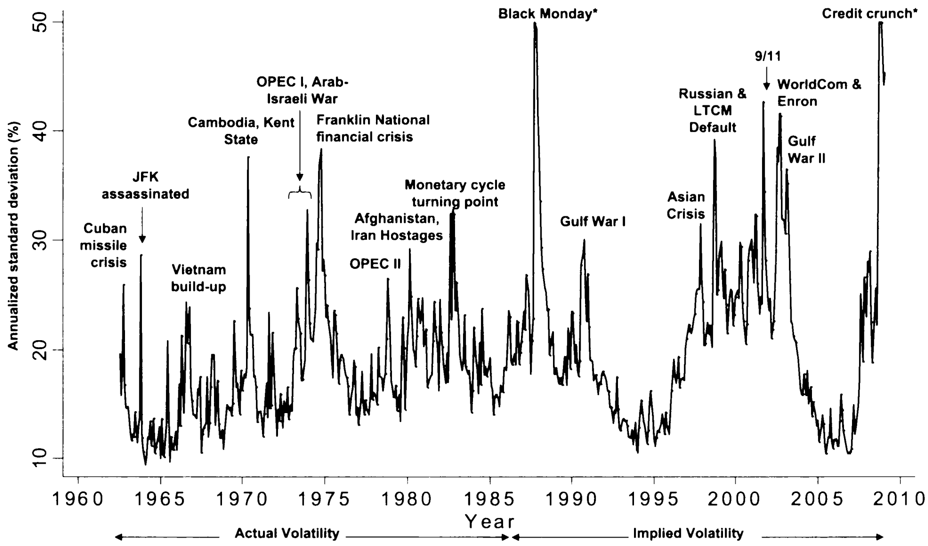

Figure 1 – Monthly U.S. stock market volatility. Source: Bloom (2009)

My baseline VAR model also includes the gross domestic product (GDP), the consumer price index (CPI), a country risk measure, the nominal exchange rate and a domestic nominal interest rate. The literature of SOE-RBC gives a great share of importance to country risk as a channel of transmission of international events. It is expected that uncertainty shocks will be mostly transmitted to the domestic economy through them, justifying its inclusion. Country risk is measured by the Emerging Market Bond Index Global (EMBIG), calculated by J.P. Morgan Chase.

In an attempt to obtain further evidences on how these shocks are transmitted, I extend the model by including a measure of trade balance, in this case the ratio of exports over imports and a measure of foreign exchange market intervention. The countries in the sample are known to have performed interventions in the exchange rate market and the shocks considered are particularly relevant for the exchange rate volatility in these economies. The idea here was to check if the initial results would prevail after controlling for interventions in the FOREX market. Brazil, Colombia and Peru disclose their data on foreign exchange intervention. Chile and Mexico do not, so I use variations in international reserves as proxy, which should be interpreted with caution, since not all variation in international reserves is due to intervention in the foreign exchange market.

The model is estimated in quarterly frequency with the sample beginning in the first quarter of 2000 and ending in the third quarter of 2015, with the exception of Chile, which ends in the last quarter of 2014. There are few caveats in estimating the model in quarterly frequency. For example, the VIX index has a high-frequency nature and quarterly aggregation might smooth its variation. Additionally, as it will be made clear in section 2.4, the identification structure is based on zero restrictions, and this kind of restrictions is harder to justify in the presence of quarterly frequency. However, quarterly economic data is more readily available, facilitating cross-countries comparisons and they are normally of better quality. The main alternative would be to use monthly data, but this would require using industrial production as a proxy for GDP and for the countries here analyzed this could posit a problem, given their lower level of industrialization, potentially misrepresenting the true dynamics of their economies. All variables enter in logarithm of their respective levels, with the exception of the nominal interest rate that enters in level. Since the variable of intervention in the foreign exchange market assume both negative and positive values, it is transformed using the relation $\tilde{x} = ln(x + \sqrt{x^2 + \sigma_x^2}) - ln(\sqrt{\sigma_x^2})$, where σ_x denotes the standard deviation of x, an approach used by both Busse e Hefeker (2007) and Rohe e Hartermann (2015). Further details about the data can be found in the Appendix. Finally, the system is estimated with 4 lags, which is standard when using quarterly data.

2.2 Methodology

The exposition done in this section follows closely Waggoner e Zha (2003, p. 351–354). The empirical model used to study how emerging economies reacts to external shocks is based on a general SVAR of the form:

$$y_t^{'} A_0 = \sum_{\ell=1}^{L} y_{t-l}^{'} A_\ell + z_t^{'} D + \varepsilon_t^{'} \tag{2.1}$$

where $t = 1, ..., T$ is the time index, $\ell = 1, ..., L$ is the lag length. A_0 and A_l are $n \times n$ parameter matrices, the first one containing the contemporaneous relations while the second contains the lagged parameters. D is an $h \times n$ parameter matrix for the vector $n \times 1$ of exogenous variables z_t, y_t is an $n \times 1$ vector of endogenous variables, and ε_t is an $n \times 1$ vector of structural disturbances. Note that the way the VAR is specified, the parameters of individual equations in 2.1 correspond to the columns of A_0, A_ℓ and D.

As will be explained in the next section, equation 2.1 is estimated using Bayesian techniques. It is useful to rewrite 2.1 in a compact form by stacking variables to obtain

$$y_t^{'} A_0 = x_t^{'} F + \varepsilon_t^{'} \tag{2.2}$$

where $\underset{1\times k}{x_t^{'}} = [y_{t-1}^{'} \ ... \ y_{t-p}^{'} \ z_t^{'}]$, $\underset{n\times k}{F^{'}} = [A_1^{'} \ ... \ A_L^{'} \ D^{'}]$, and $k = np \cdot h$. Although in this specification $F^{'}$ includes exogenous parameters, for the sake of exposition it will be referred as lagged parameters.

For $1 \leq i \leq n$, let a_i be the ith column of A_0, representing the ith equation for the contemporaneous relation in A_0, let f_i be the ith column of F, representing the lag structure for the ith equation, let Q_i be an $n \times n$ matrix of rank q_i, and let R_i be an $k \times k$ matrix of rank r_i. The linear restrictions of interest can be summarized as follows:

$$Q_i a_i = 0 \ , \ i = 1, ..., n. \tag{2.3}$$

$$R_i f_i = 0 \ , \ i = 1, ..., n. \tag{2.4}$$

It is used a prior developed by Sims e Zha (1998) to specify the prior distribution of a_i and f_i. More details about this prior can be found on section 2.3. The prior is assumed to be Gaussian with mean zero and covariance matrix $\bar{\Sigma}$ and can be rewritten as:

$$a_i \sim \mathcal{N}(0, \bar{S}_i) \text{ and } f_i | a_i \sim \mathcal{N}(\bar{P}_i a_i, \bar{H}_i) \tag{2.5}$$

where $\bar{S}_i$ is an $n \times n$ symmetric positive definite (SPD) matrix, $\bar{H}_i$ is a $k \times k$ SPD matrix, and $\bar{P}_i$ is a $k \times n$ matrix. Note that these matrix are all function of $\bar{\Sigma}$. It is convenient to obtain a functional form of the conditional prior distribution. Combining the prior form 2.5 with the restrictions 2.3 and 2.4, we obtain

$$q(a_i, f_i | Q_i a_i = 0; R_i f_i = 0) \tag{2.6}$$

Suppose that U_i is an $n \times q_i$ matrix whose columns form an orthonormal basis for the null space of Q_i and V_i be a $k \times r_i$ matrix whose columns form an orthonormal basis for the null space of R_i. Waggoner e Zha (2003) show that the columns a_i and f_i will satisfy the restrictions 2.3 and 2.4 if and only if there exist a $q_i \times 1$ vector b_i and an $r_i \times 1$ vector g_i such that

$$a_i = U_i b_i \tag{2.7}$$

$$f_i = V_i g_i \tag{2.8}$$

Thus the distribution of b_i and g_i is given by

$$b_i \sim \mathcal{N}(0, \tilde{S}_i) \text{ and } g_i | b_i \sim \mathcal{N}(\tilde{P}_i b_i, \tilde{H}_i) \tag{2.9}$$

where

$$\begin{aligned}
&\tilde{H}_i = (V_i' \bar{H}_i^{-1} V_i)^{-1}, \\
&\tilde{P}_i = \tilde{H}_i V_i' \bar{H}_i^{-1} \bar{P}_i U_i, \\
&\tilde{S}_i = (U_i' \bar{S}_i^{-1} U_i + U_i' \bar{P}_i' \bar{H}_i^{-1} \bar{P}_i U_i - \tilde{P}_i' \tilde{H}_i^{-1} \tilde{P}_i)^{-1}
\end{aligned}$$

Let $b = [b_1' \ ... \ b_n']$, $g = [g_1' \ ... \ g_n']$, $X = [x_1 \ ... \ x_T]'$, and $Y = [y_1 \ ... \ y_T]'$. The likelihood function for b and g is proportional to

$$|det[U_1 b_1| \ ... \ |U_n b_n]|^T exp\bigg(- \frac{1}{2} \sum_{i=1}^{n} (b_i' U_i' Y' Y U_i b_i - 2 g_i' V_i' X' Y U_i b_i + g_i' V_i' X' X V_i g_i) \bigg) \quad (2.10)$$

Combining the prior in 2.9 with the likelihood function given by 2.10 leads to the following joint posterior pdf of b and g:

$$p(b_1, ..., b_n | X, Y) \prod_{i=1}^{n} p(g_i | b_i, X, Y),$$

where

$$p(b_1, ..., b_n | X, Y) \propto |det[U_1 b_1|...|U_n b_n]|^T exp\bigg(- \frac{T}{2} \sum_{i=1}^{n} b_i' S_i^{-1} b_i \bigg), \quad (2.11)$$

$$p(g_i | b_i, X, Y) = \varphi(P_i b_i, H_i), \quad (2.12)$$

with

$$\begin{aligned} H_i &= (V_i' X' X V_i + \tilde{H}_i^{-1})^{-1}, \\ P_i &= H_i (V_i' X' Y U_i + \tilde{H}_i^{-1} \tilde{P}_i), \\ S_i &= (\frac{1}{T} (U_i' Y' Y U_i + \tilde{S}_i^{-1} + \tilde{P}_i' \tilde{H}_i^{-1} \tilde{P}_i - P_i' H_i^{-1} P_i))^{-1} \end{aligned}$$

where $\varphi(P_i b_i, H_i)$ denotes the Gaussian density with mean $P_i b_i$ and covariance matrix H_i.

To obtain inferences of b and g or their functions, it is necessary to simulate the joint posterior distribution of b and g. This is done by a Gibbs sampler developed by Waggoner e Zha (2003), which has better performance in terms of finite-sample accuracy than other methods used in previous studies like Leeper, Sims e Zha (1996) and Zha (1999). The interested reader can refer to Waggoner e Zha (2003) for a detailed explanation of the Gibbs sampler and theorem proofs.

Equation 2.2 is the structural form of the VAR system. However, in this form the VAR suffers from the problem of endogeneity, therefore, it can't be estimated by OLS while in this form. In order to be able to estimate the system it is necessary to obtain the reduced form of the VAR. This is done by multiplying both sides of equation 2.2 by A_0^{-1}, which yields:

$$y_t' = x_t' B + E \quad (2.13)$$

where $B = A_0^{-1} F$ and $E = A_0 \varepsilon_t'$. The VAR in the form of equation 2.13 has contemporary correlation between the errors. This fact will be used to identify the parameters of the structural model described by equation 2.1. In fact, when using equation 2.13 to estimate the system, some information are lost such that without further assumptions it is impossible to identify the structural parameters, hence, it is necessary to impose restrictions in the VAR equations in order to the estimates have meaningful economic information. Details about the identification scheme used here can be found in Section 2.4.

2.3 Priors

Despite its intense use in applied macroeconomics, VARs suffer from a well known problem of overparameterization. Normally, this problem occur when there is a large number of parameters to be estimated, when there are relatively few observations and when the estimation method is designed to yield the closest fit to the data. All of these conditions to overparameterization can be found in VAR models. The parameters to be estimated grows exponentially due to inclusion of an extra variable or lag, macroeconomic data is often scarce and OLS is a method that will provide the closest fit to the data. In this work it is used Bayesian estimation, which is a simple but yet powerful method to tackle the model shortcomings.

One of the drawbacks of Bayesian estimation is its heavily computational burden. It is common in VAR estimation to come across with the inversion of matrices with very large dimensions in order to compute the mean of the conditional posterior distribution. This impose a considerably computational constraint. An alternative to handle this restriction is to impose prior information via dummy observations or artificial data. Informally speaking, this involves generating artificial data from the model assumed under the prior and mixing it with the actual data. The weight placed on the artificial data determines how tightly the prior is imposed. Therefore, in this work it is used a prior developed by Sims e Zha (1998) which are in the form of conjugate dummy observations priors.

To see how dummy observations can be used as priors, an example from a simple linear regression is useful. Consider the following linear regression:

$$y_t = x_t\beta + u_t, \text{ with } u_t \sim i.i.d.\mathcal{N}(0, \sigma^2) \tag{2.14}$$

The likelihood for only one observation would be:

$$\mathcal{L}(y_t|\beta, \sigma^2(, x_t, Model)) = (2\pi\sigma^2)^{-\frac{1}{2}} exp\Bigg(- \frac{1}{2}\frac{(y_t - x_t\beta)^2}{\sigma^2}\Bigg) \tag{2.15}$$

The likelihood for the whole sample, thus, will be:

$$\mathcal{L}(y_1, ..., y_T|\beta, \sigma^2) = (2\pi\sigma^2)^{-\frac{T}{2}} exp\Bigg(- \frac{1}{2}\frac{\sum_{t=1}^{T}(y_t - x_t\beta)^2}{\sigma^2}\Bigg) \tag{2.16}$$

Assuming that the prior for β is Normal with mean $\tilde{\beta}$ and variance $\tilde{q}\sigma^2$, we have:

$$p(\beta|\sigma^2) = (2\pi\tilde{q}\sigma^2)^{-\frac{1}{2}} exp\Bigg(-\frac{1}{2}\frac{(\beta-\tilde{\beta})^2}{\tilde{q}\sigma^2}\Bigg) \tag{2.17}$$

The posterior density of β will be proportional to the product of the likelihood in equation 2.16 with the prior in equation 2.17, therefore:

$$\begin{aligned}
&= (2\pi\sigma^2)^{-\frac{T}{2}} exp\Bigg(-\frac{1}{2}\frac{\sum_{t=1}^{T}(y_t - x_t\beta)^2}{\sigma^2}\Bigg)(2\pi\sigma^2\tilde{q})^{-\frac{1}{2}} exp\Bigg(-\frac{1}{2}\frac{(\beta-\tilde{\beta})^2}{\sigma^2\tilde{q}}\Bigg) \\
&\propto exp\Bigg(-\frac{1}{2}\frac{\sum_{t=1}^{T}(y_t - x_t\beta)^2}{\sigma^2} - \frac{1}{2}\frac{(\beta-\tilde{\beta})^2}{\sigma^2\tilde{q}}\Bigg) \\
&\propto exp\Bigg(-\frac{1}{2}\frac{\sum_{t=1}^{T}(y_t - x_t\beta)^2 + (\frac{1}{\sqrt{\tilde{q}}}\tilde{\beta} - \frac{1}{\sqrt{\tilde{q}}}\beta)^2}{\sigma^2}\Bigg)
\end{aligned} \tag{2.18}$$

It is easy to see from equation 2.18 that the posterior looks like the likelihood of a sample of $T+1$ observations. If we define the dummy observations as $\tilde{y} = {}^1/_{\sqrt{\tilde{q}}}\tilde{\beta}$ and $\tilde{x} = {}^1/_{\sqrt{\tilde{q}}}$ and denoting our augmented sample as $\bar{y} = (y_1, y_2, ..., y_T, \tilde{y})$ and $\bar{x} = (x_1, x_2, ..., x_T, \tilde{x})$, the posterior density of β will be:

$$\begin{aligned}
p(\beta|\sigma^2, y) &\propto exp\Bigg(-\frac{1}{2}\frac{\sum_{t=1}^{T}(y_T - x_t\beta)^2 + (\frac{1}{\sqrt{\tilde{q}}}\tilde{\beta} - \frac{1}{\sqrt{\tilde{q}}}\beta)^2}{\sigma^2}\Bigg) \\
&\propto exp\Bigg(-\frac{1}{2}\frac{(\bar{y}-\bar{x}\beta)'(\bar{y}-\bar{x}\beta)}{\sigma^2}\Bigg) \\
&\propto exp\Bigg(-\frac{1}{2}\frac{\bar{s} + (\beta-\bar{\beta}_{ols})'\bar{x}'\bar{x}(\beta-\bar{\beta}_{ols})}{\sigma^2}\Bigg) \\
&\propto exp\Bigg(-\frac{1}{2}\frac{(\beta-\bar{\beta}_{ols})'\bar{x}'\bar{x}(\beta-\bar{\beta}_{ols})}{\sigma^2}\Bigg) \\
&\propto \mathcal{N}(\bar{\beta}_{ols}, \sigma^2(\bar{x}'\bar{x})^{-1})
\end{aligned} \tag{2.19}$$

where $\bar{\beta}_{ols} = (\bar{x}'\bar{x})^{-1}\bar{x}'y$ and $\bar{s} = (\bar{y} - \bar{x}\bar{\beta}_{ols})'(\bar{y} - \bar{x}\bar{\beta}_{ols})$. We can obtain useful information from the posterior mean:

$$
\begin{aligned}
\bar{\beta}_{ols} = (\bar{x}'\bar{x})^{-1}\bar{x}'y &= \left(\sum_{t=1}^{T+1} \bar{x}_t^2\right)^{-1} \sum_{t=1}^{T+1} \bar{x}_t \bar{y}_t \\
&= \left(\sum_{t=1}^{T} \bar{x}_t^2 + \frac{1}{\tilde{q}}\right)^{-1} \left(\sum_{t=1}^{T} x_t y_t + \frac{1}{\tilde{q}}\tilde{\beta}\right) \\
&= \left(\sum_{t=1}^{T} x_t^2 + \frac{1}{\tilde{q}}\right)^{-1} \left(\left(\sum_{t=1}^{T} x_t^2\right)\left(\sum_{t=1}^{T} x_t^2\right)^1 \sum_{t=1}^{T} x_t y_t + \frac{1}{\tilde{q}}\tilde{\beta}\right) \\
&= \left(\sum_{t=1}^{T} x_t^2 + \frac{1}{\tilde{q}}\right)^{-1} \left(\left(\sum_{t=1}^{T} x_t^2\right)\beta_{ols} + \frac{1}{\tilde{q}}\tilde{\beta}\right) \\
&= \left(\sum_{t=1}^{T} x_t^2 + \frac{1}{\tilde{q}}\right)^{-1} \left(\sum_{t=1}^{T} x_t^2\right)\beta_{ols} + \left(\sum_{t=1}^{T} x_t^2 + \frac{1}{\tilde{q}}\right)^{-1} \left(\frac{1}{\tilde{q}}\right)\tilde{\beta}
\end{aligned}
\tag{2.20}
$$

Therefore, the posterior mean is a weighted average:

$$E(\beta|y) = \bar{\beta}_{ols} = w_1\beta_{ols} + w_2\tilde{\beta}$$

where

$$
\begin{aligned}
w_1 &= \left(\sum_{t=1}^{T} x_t^2 + \frac{1}{\tilde{q}}\right)^{-1} \left(\sum_{t=1}^{T} x_t^2\right) \\
w_2 &= \left(\sum_{t=1}^{T} x_t^2 + \frac{1}{\tilde{q}}\right)^{-1} \left(\frac{1}{\tilde{q}}\right) \\
w_1 + w_2 &= 1
\end{aligned}
$$

Note that the prior variance $\tilde{q}$ determines the relative weight of β_{ols} and $\tilde{\beta}$. In other words, the more informative the prior is (e.g the smaller the variance), the more weight the dummy observation has in the posterior.

As stated before, the prior considered in this work follows the conjugate dummy observation prior proposed by Sims e Zha (1998). The motivation behind this prior is explained in Sims (2000). Basically, when using VAR we have two problems. The first is that VAR has too many parameters to be estimated which normally yields a poor out-of-sample forecasting. Actually, unrestricted VARs forecasts worse than univariate random walk models. Therefore, it is necessary to restrict some of these excessive parameters. An obvious solution is to estimate a VAR with a random walk prior, like the Minnesota Prior. The other problem is that VAR is analyzed with the conditional likelihood, instead of the exact likelihood. This create a tendency to underestimate persistence in the model. To understand this, consider an $AR(1)$ model:

$$y(t) = \alpha + \rho y(t-1) + u(t)$$

The conditional likelihood is conditional on the initial observation $y(0)$, while in the exact likelihood all the observations, including the initial, are conditional on the parameters of the model. Formally, the conditional likelihood is:

$$p(y(1), ..., y(T)|\alpha, \rho, y(0)) = p(y(1)|y(0), \alpha, \rho) \times p(y(2)|y(1), \alpha, \rho) \times ... \times p(y(T)|y(T-1), \alpha, \rho)$$

And the exact likelihood is:

$$p(y(0), y(1), ..., y(T)|\alpha, \rho) = p(y(1), ..., y(T)|\alpha, \rho, y(0)) \times p(y(0)|\alpha, \rho)$$

However, $y(0)$ comes from the ergodic distribution:

$$p(y(0)|\alpha, \rho) = \mathcal{N}\left(\frac{\alpha}{1-\rho}, \frac{\sigma^2}{1-\rho^2}\right)$$

The problem is that the ergodic distribution only exists when the process is stationary, so $|\rho| < 1$. Therefore, we need, by assumption, to rule out unit root or slightly explosive behaviour in our model. This is a strong assumption, specially in macroeconomics. Also, nonlinear terms in $p(y(0)|\alpha, \rho)$ complicate the algebra in obtaining the exact likelihood. Given these constraints, most researchers use the conditional likelihood.

The effect of using the conditional likelihood instead of the exact likelihood is that we underestimate persistence. In Bayesian perspective this is called the spurious explanatory power of the initial condition, while in frequentist perspective this is considered to be the small sample bias in autoregressions. This spurious explanatory power of the initial condition occurs in Bayesian estimation because there is no term for $y(0)$ in the likelihood, so the researcher is free to believe in parameter values that imply something unreasonable about $y(0)$. For example, when we observe a growing variable we could interpret that this is a stationary variable that just happened to start far from its mean, instead to interpret as to be the consequence of a trend in the variable.

To account for these two problems cited above, we could implement priors that softly restrict the coefficients towards zero; softly restrict the coefficients of the first lag to 1; and softly restrict the coefficients towards values that imply unit roots. This is exactly what the prior developed by Sims e Zha (1998) do. This prior is the combination of three unit roots priors: the Minnesota prior, the sum-of-coefficients prior and the dummy-initial-observation prior.

The Minnesota prior imposes the restriction that coefficients on the first lag has prior mean of 1. In the approach by Sims e Zha (1998), this is done by creating the variables such that for the i'th equation, a set of *k-1* dummy observations, indexed by $j = 1, ..., m$, $l = 1, ..., p$, is inserted in the data sample, with data taking the values specified by equation

2.21:

$$y_i(r,j)\ ;\ r=1,...,k-1; j=1,...,m = \begin{cases} \mu_1\mu_2\sigma_r/l^{\mu_4}, & \text{if } r=j, r\leq m \\ 0, & \text{otherwise} \end{cases}$$

$$x_i(r,s)\ ;\ r=1,...,k-1; s=1,...,k-1 = \begin{cases} \mu_1\mu_2\sigma_r/l^{\mu_4}, & \text{if } r=s, \\ 0, & \text{otherwhise} \end{cases} \tag{2.21}$$

where μ_1, μ_2 and μ_4 are hyperparameters, with μ_1 controlling the overall tightness and also for A_0, μ_2 controls the relative tightness of the matrix A_X, and μ_4 controls the tightness on lag decay. These hyperparameters are set at its default values, which are, respectively, 1, 0.5 and 1.

The sum-of-coefficients prior is for the case when the variables in the VAR have a unit root, so this information can be reflected via a prior that incorporates the belief that coefficients on lags of the dependent variable sum to 1. In a system of m equations, l lags and k coefficients, it introduces m observations, indexed by i, of the form:

$$y(i,j)\ ;\ i=1,...,m; j=1,...,m = \begin{cases} \mu_5\bar{y}_{0i}, & \text{if } i=j, \\ 0, & \text{otherwise} \end{cases}$$

$$x(i,s)\ ;\ i=1,...,m; s=1,...,k = \begin{cases} \mu_5\bar{y}_{0i}, & \text{if } i=j,\ \text{all l}\ , \\ 0, & \text{otherwise} \end{cases} \tag{2.22}$$

where $\bar{y}_{0i}$ is the average of initial values of variable i and μ_5 is a hyperparameter that controls the weight of the prior. For instance, as $\mu_5 \to \infty$, the model tends to a form that can be expressed entirely in terms of differenced data. In this work this hyperparameter is set in its default value, which is 1.

The dummy-initial-observation prior express the prior belief that the variables in the VAR have a common stochastic trend. This is done according equation 2.23:

$$y(j)\ ;\ j=1,...,m = \mu_6\bar{y}_{0j}$$

$$x(s)\ ;\ s=1,...,k \begin{cases} \mu_6\bar{y}_{0j}, & \text{if } s\leq k-1, \\ \mu_6, & \text{if } s=k \end{cases} \tag{2.23}$$

where μ_6 is a hyperparameter that controls the weight on single dummy initial observation. For instance, as $\mu_6 \to \infty$, the model tends to a form in which either all variables are stationary with means equal to the sample averages of the initial conditions, or there are unit root components without drift terms. In this work, this hyperparameter is set at its default value, which is 1.

2.4 Identification

I study small open emerging economies, so it is assumed that they do not have the capacity to influence international economic variables. When using VAR to model these type of economies, this assumption is often overlooked. Since VAR basically captures correlation among variables in the system, it will capture co-movements between international and domestic variables without assuming any causality between them. Hence, we will see international variables responding to innovations in domestic variables which is not a reasonable assumption.

This work follows Cushman e Zha (1997) and imposes block exogeneity[2], which helps to identify policy reaction from the point of view of the small open economy, as well as it reduces the number of parameters to be estimated. Following Cushman e Zha (1997) and Zha (1999), note that we can represent the VAR model as:

$$A(L)y(t) = \varepsilon(t) \tag{2.24}$$

where $t = 1, ..., T$, A(L) is an $M \times M$ matrix of non-negative-power polynomials in lag operators with lag length p, $y(t)$ is an $m \times l$ vector of observations and $\varepsilon(t)$ is an $m \times l$ vector of structural disturbances or shocks with

$$y(t) = \begin{bmatrix} y_1(t) \\ y_2(t) \end{bmatrix}, \qquad A(L) = \begin{bmatrix} A_{11} & A_{12}(L) \\ 0 & A_{22}(L) \end{bmatrix}, \qquad \varepsilon(t) = \begin{bmatrix} \varepsilon_1(t) \\ \varepsilon_2(t) \end{bmatrix} \tag{2.25}$$

In this setup, we divide our sample in two blocks, an international and a domestic block. Here, the vector $y_1(t)$ represents the domestic block and has dimension $m_1 \times l$, while the vector $y_2(t)$ represents the international block and has dimension $m_2 \times l$. Furthermore, $A_{11}(L)$ is $m_1 \times m_1$, $A_{12}(L)$ is $m_1 \times m_2$, $A_{22}(L)$ is $m_2 \times m_2$, while $\varepsilon_1(t)$ is of order $m_1 \times l$ and $\varepsilon_2(L)$ is $m_2 \times l$. Note that $m_1 + m_2 = m$.

The restriction $A_{12} = 0$ imposes the assumption of small open economy. This implies that domestic innovations in $\varepsilon_1(t)$ do not affect the international block $y_2(t)$ either contemporaneously or with lags in the structural form in equation 2.24. In the framework presented in section 2.2, the imposition of block recursion means to restrict the matrix R_i presented in equation 2.4 in order to guarantee that VIX and commodity prices are not impacted in the dynamic by the other variables. Additionally, it is assumed that the VIX equation follows an AR(4) process, because it is not reasonable to assume that commodity prices fluctuations will impact the stock market volatility, the causality is the other way around. Block exogeneity is also imposed in the country risk equation. In the literature there is no consensus on how to model this variable. Neumeyer e Perri (2005) assumes the country risk being completely exogenous to the remaining domestic variables he includes in the model. One may also argue that country risk should be closely related to long

[2] For a more detailed explanation and mathematical proofs, refer to Zha (1999)

run fiscal perspectives, which I do not intend to model in this work. For these reasons, I impose the restriction that risk premium will be affected by its autoregressive structure and by the international variables. Other advantage of modelling country risk in this way is that we can impose the right causality between country risk and exchange rate, which are closely correlated, but it is the former that influence the latter. At Appendix D, the baseline model is estimated assuming different hypothesis regarding the block structure, and it can be seen that the results are not qualitatively changed.

As stated before, the VAR is estimate in its reduced form. In order to recover the structural parameters we need to impose additional restrictions. I follow the informational method of identification proposed by Leeper, Sims e Zha (1996) in which the variables only react contemporaneously to shocks if the information related to these shocks is available within the period considered. In accordance with the model presented in section 2.2, contemporaneous relations are modeled by imposing zero restrictions in the matrix Q_i presented in equation 2.3. Therefore, it is imposed the following structure on contemporaneous relations:

$$A_0 = \begin{array}{c} \\ GDP \\ CPI \\ VIX \\ PCOM \\ CR \\ EXR \\ INTR \end{array} \begin{array}{c} \begin{array}{ccccccc} GDP & CPI & VIX & PCOM & CR & EXR & INTR \end{array} \\ \begin{bmatrix} a_{1,1} & a_{1,2} & 0 & 0 & 0 & 0 & a_{1,7} \\ 0 & a_{2,2} & 0 & 0 & 0 & 0 & a_{2,7} \\ a_{3,1} & a_{3,2} & a_{3,3} & a_{3,4} & a_{3,5} & a_{3,6} & a_{3,7} \\ a_{4,1} & a_{4,2} & 0 & a_{4,4} & a_{4,5} & a_{4,6} & a_{4,7} \\ 0 & 0 & 0 & 0 & a_{5,5} & a_{5,6} & a_{5,7} \\ 0 & 0 & 0 & 0 & 0 & a_{6,6} & a_{6,7} \\ 0 & 0 & 0 & 0 & 0 & 0 & a_{7,7} \end{bmatrix} \end{array} \tag{2.26}$$

Basically, there are three blocks. The real block composed by GDP and CPI, the international block, composed by the VIX index and commodity prices, PCOM. Finally, there is the financial block which comprehend the country risk, CR, the exchange rate and the domestic interest rate. Note that in 2.26 the columns represent the equations of the system which is the same to say that the i_{th} row shows which variables (columns) are affected by a shock in the i_{th} variable.

Zha (1999) explains the necessity to identify the international block with a Cholesky ordering, because in the estimation process the block structure might be lost once the matrix is inverted. It is assumed that VIX index affects contemporaneously commodity prices, since uncertainty will drive commodity prices, not the contrary. Since it is used quarterly data, it is reasonable to assume that VIX and commodity prices will affect contemporaneously the real variables. It is assumed that country risk and exchange rate will be affected contemporaneously by changes in the international block only. Given its forward-looking characteristic, it would also be reasonable to assume that the exchange rate would react to changes in every variable in the system, however, the assumption made here is that exchange rate will be mostly affected by changes in global financial conditions, while domestic conditions will be of less importance. Finally, it is assumed that the monetary authority have full information about the economy and will contemporaneously react to shocks in every single variable of the system.

3 The role of uncertainty and commodity prices shocks in emerging economies

The goal of this work is to analyze how external shocks impact emerging economies. Since all countries analyzed here are net commodity exporters, it is focused on two shocks: an uncertainty and a commodity price shock. It is surprising that these shocks have rarely been analyzed together, specially because the oscillation in commodity prices may cause different response in the domestic economy depending of the source of the innovation.

In this section[1], the impulse responses with their respective 68% probability band[2] are presented. Although every country in the sample will be analyzed, for the sake of clarity only the impulse responses of Brazilian variables are shown, while the impulse responses of other economies can be found at Appendix A, in figures 9 to 19.

3.1 Commodity price shock

Before analyzing the impulse responses to a commodity price shock, it might be enlightening to investigate to which degree are the countries in the sample dependent on their commodity sector. Figure 2 shows the ratio of commodity exports over net exports and commodity exports over GDP[3] with 2012 data.

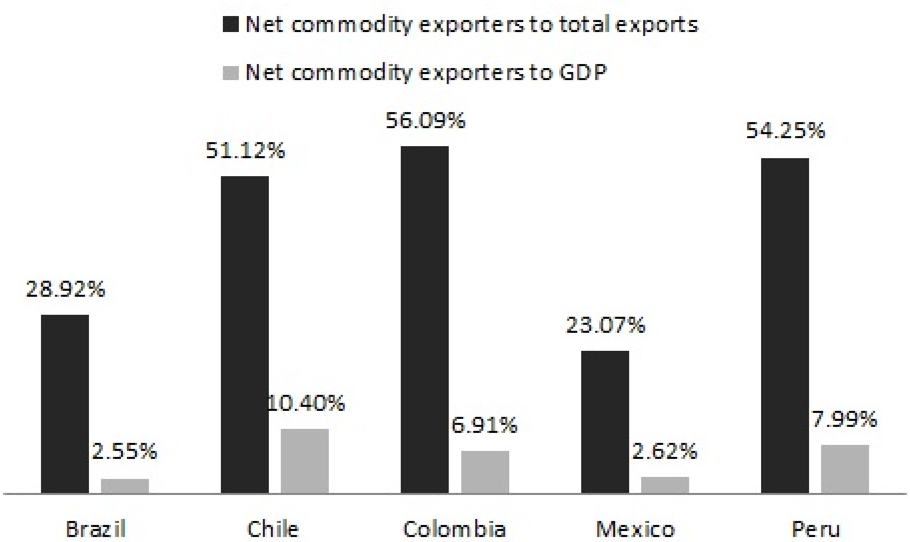

Figure 2 – The importance of commodities for Brazil, Chile, Colombia, Mexico and Peru

[1] The results were obtained using Matlab, version R2012b. The code used is based on the code made publicly available by Tao Zha at http://www.tzha.net/code.
[2] These probability bands were computed using the method developed by Sims e Zha (1999).
[3] Data obtained from IMF (2012) and available at http://www.imf.org/external/pubs/ft/weo/2012/01/.

As can be seen, every country in the sample is a net exporter of commodity and it represents a big share of exports, less for Brazil and Mexico which has a more diversified economy, nevertheless, their dependency on commodity exports is considerable. From figure 2 we can predict that a rise in commodity prices will have expansive effects throughout these economies.

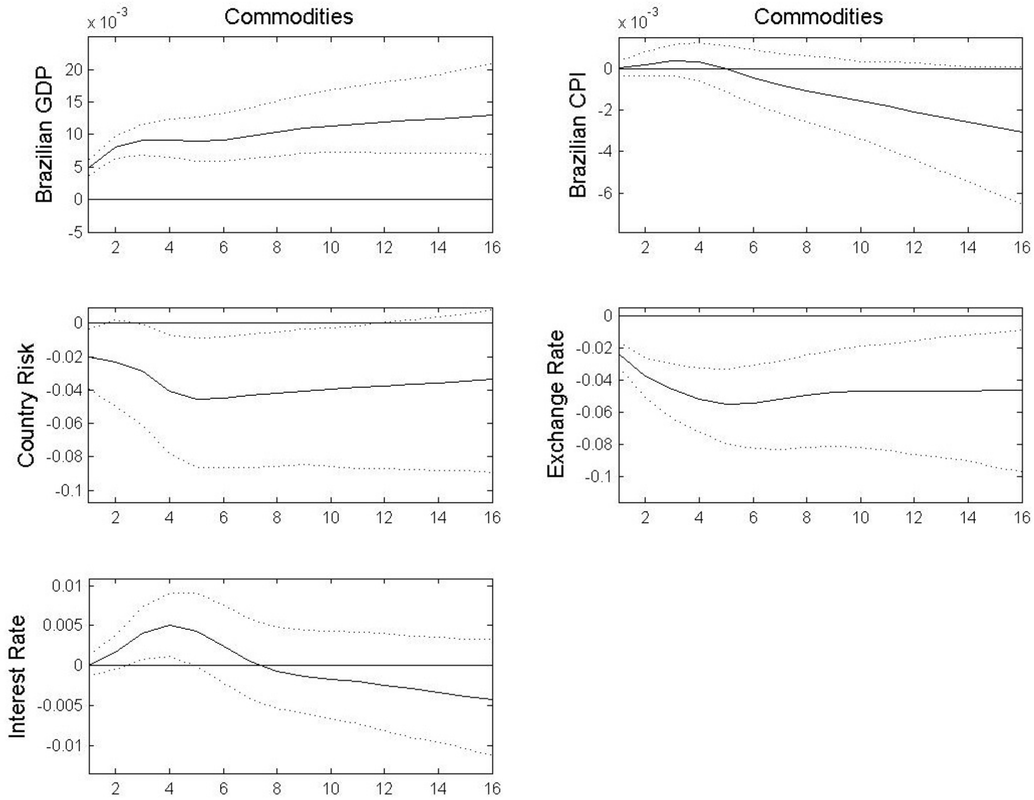

Figure 3 – Response of Brazilian variables to a commodity price shock

Figure 3 shows the response of Brazilian variables to a positive shock in commodity prices. We can see that GDP responds positively, which is also true for the other countries, with the exception of Chile, where it starts to contracts sometime around the $6th$ quarter after the shock. The exchange rate strongly appreciates, since it is expected that a rise in commodity prices will increase capital flow, reducing risks associated to balance of payment problems, as shown by the decline in country risk. The shock produces inflation in every country, suggesting that increases in cost and/or more intense economic activity dominate the exchange rate appreciation. Inflation would possibly increase more if central banks did not react by increasing the policy interest rate, as shown in plots.

The response of Chile is quite unexpected given its economic openness and its dependency on commodity exports. However, Gregorio e Labbé (2011) documents that since the adoption of inflation targeting, flexible exchange rate and rule-based fiscal policy, Chile has verified a decrease in economic volatility due to shocks in the price of copper.

The authors argue that fiscal and monetary policy have complemented each other in Chile, reducing business cycle volatility and the dependence of Chile's economic performance to copper price fluctuations. This may explain why Chile is the only country in the sample to react in a distinct manner to commodity shock.

3.2 Uncertainty shock

Economic uncertainty has been in the spotlight in the last few years due to its real impacts. Several studies for industrialized countries have found that a rise in uncertainty decreases output for a few periods, but economic activity return to normal soon after the spike in uncertainty. Bloom (2009) develops a dynamic model that accounts for uncertainty and the main result is that the model yields a central region of inaction in hiring and investing. Firms will only invest when the conditions are good enough and only disinvest when the conditions are bad enough. Uncertainty has a central role in this region of inaction because when uncertainty increases, this region expand, since the option of "wait and see" becomes more valuable. However, uncertainty shocks are often short lived, explaining why output falls but returns to its previous path soon after.

The works that analyze how uncertainty shocks are transmitted through emerging economies find evidences that their contraction is longer than industrialized countries. Carrière-Swallow e Céspedes (2013) finds evidences that uncertainty shocks has a deeper and longer contractionary effect on emerging economies and this might be because of financial markets that are not fully developed. My results points in the same direction. Figure 4 shows the response of Brazilian variables to a rise in uncertainty, measured by an increase in the VIX index.

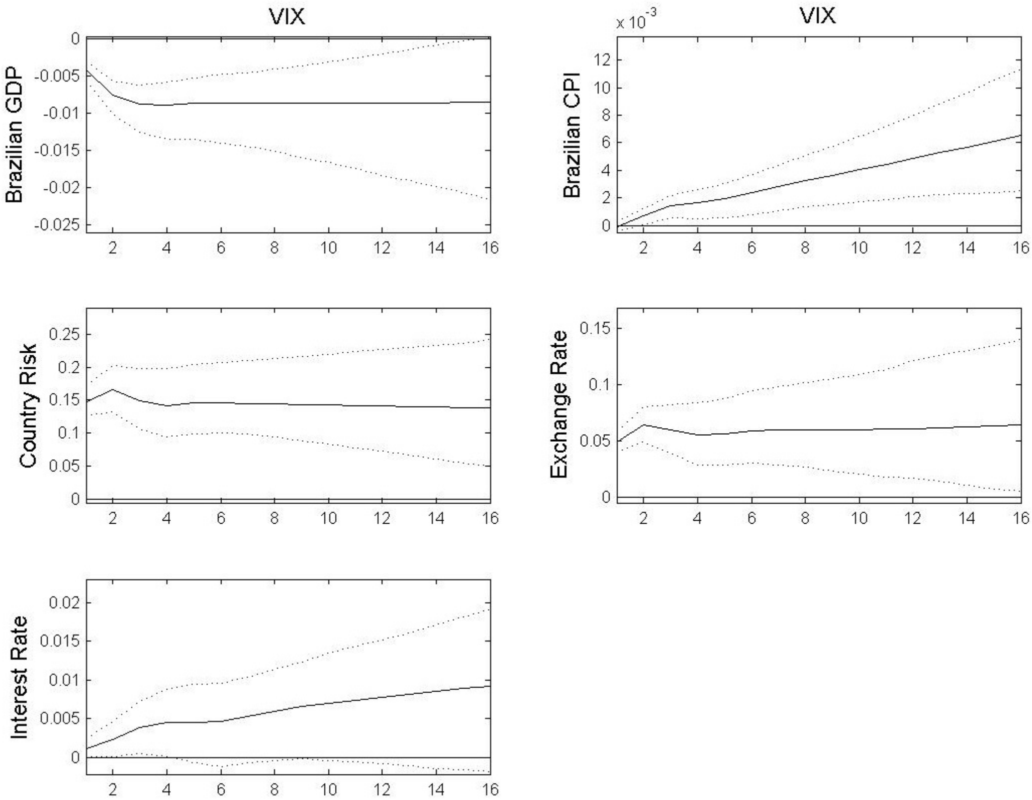

Figure 4 – Response of Brazilian variables to a VIX shock

Since in VAR the impulse responses are symmetrical, I am going to analyze the effects of a reduction in global economic uncertainty, in order to have results comparable to the commodity prices shocks, providing interesting insights.

We can see that with the exception of Chile, Latin American economies observes a strong positive reaction of GDP. In Chile not only the positive impact is considerably smaller, output starts to decrease sometime around the 6th quarter after the shock, a response more similar to advanced countries, as documented by Carrière-Swallow e Céspedes (2013).

A negative VIX shock results in smaller inflation in every country but Chile, which presents the same puzzling behaviour as before. For the other countries, even though a reduction in global economic uncertainty increases commodity prices, the pass-through to inflation is different. The reason for the difference resides on the more intense response of country risk, which falls 7.5 times more when compared to a commodity shock. This ultimately leads to a stronger exchange rate appreciation, which more than compensates for the increase in commodity price. So, in the presence of a reduction in world economy uncertainty, emerging countries are seen as being less risky, attracting more international funds which strongly impacts the exchange rate and, ultimately, avoiding inflationary pressures arising from higher commodity prices. This imply that central bankers should be aware of the source of commodity price fluctuation in order to set monetary policy appropriately.

3.3 The relative importance of uncertainty and commodity prices shocks

To assess how uncertainty and commodity prices shocks can explain business cycle fluctuations in emerging economies it is performed a forecast error variance decomposition for the domestic variables in response to such shocks. The results are reported in table 5, which can be found at the Appendix[4].

It can be seen that uncertainty shocks explain a high share of business cycles fluctuations in Latin American countries. GDP is highly affected by this shock. As expected, and in line with Akıncı (2013), country risk seems to be the main channel through which uncertainty shocks are transmitted to emerging economies, reinforcing the notion that when uncertainty about the American (global) economy rises, a "flight to quality" occurs. Uncertainty naturally reduces investment demand and limits credit supply and demand. Although I do not model these variables, standard RBC model would show such responses. Exchange rate and the interest rate are also largely explained by this shock.

Peru seems to be less affected by uncertainty shocks, having a relevant role in explaining variations only in country risk and interest rate. It is worth noting that uncertainty shock is the main responsible for variations in country risk in both Chile e Mexico, explaining about 75% of the variation, appearing to be the main channel of transmission. Also, while this shock is able to explain a considerable share of the variation in monetary policy, in Colombia it is less relevant.

3.4 Trade balance channel and foreign exchange interventions

The responses of Chile's GDP and CPI are quite puzzling. One characteristic of the Chilean economy that might provide answers to this puzzle is their economic openness. Figure 5 shows the ratio of total trade over GDP with 2013 data[5], and we can see that Chile and Mexico have higher degree of economic openness, being above world average, while Brazil is a relatively closed. Another characteristic of Latin American economies is that their central banks perform systematic interventions in the foreign exchange market. To account for these characteristics, I expand the model including a measure of trade balance, which in this case will be the ratio of total exports over total imports, and a measure of intervention in the foreign exchange market. As pointed out before, this variable is disclosed by the central banks of Brazil, Colombia and Peru. For Chile and Mexico I

[4] Note that the values correspond to the average of the quarters after the shock occurred.
[5] Data obtained from World Bank available at http://data.worldbank.org/indicator/NE.TRD.GNFS.ZS

use variations in international reserves as proxy, therefore, their results must be analyzed with the necessary caution.

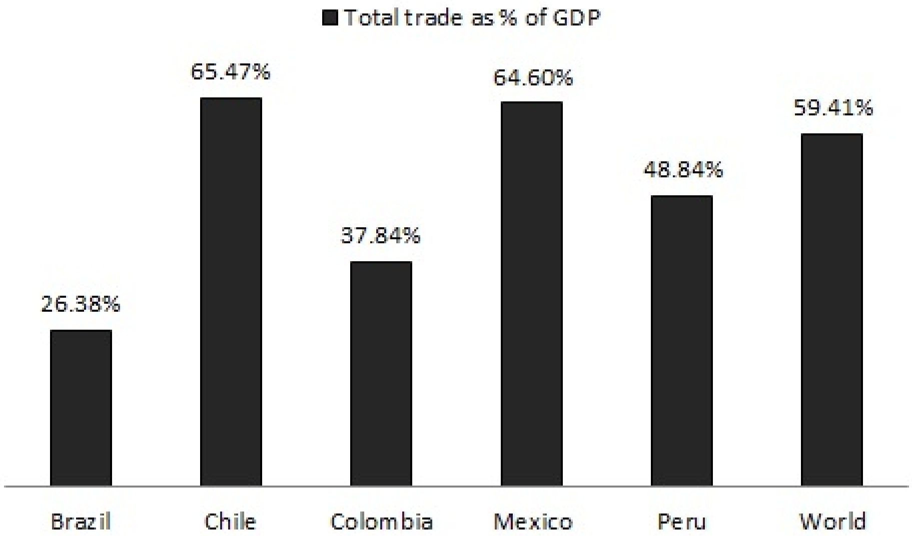

Figure 5 – Economic openness of Brazil, Chile, Colombia, Mexico and Peru with 2013 data.

The identification of the model as shown by equation 2.26 is kept the same. The trade balance equation is identified assuming that changes in GDP, VIX, commodity prices and exchange rate, can affect the trade balance contemporaneously. Given the share of exports that are commodities, it is reasonable to assume that changes in commodities' prices will affect the trade balance within the quarter. The same apply to a positive uncertainty shock, since it has the effect of reducing commodity prices and the international demand for imports, which will impact the exports of emerging markets. The inclusion of GDP and the exchange rate are quite obvious. A rise in GDP will increase the demand for imports and the exchange rate will determine the relative price between exports and imports. The foreign exchange market intervention equation is identified by assuming it will only react contemporaneously to external shocks, country risk and exchange rate shocks, since they are the main responsible for exchange rate volatility in emerging markets.

In the open economy macroeconomics with fully flexible exchange rate, the exchange rate ends being the main "shock absorber" of external and financial shocks. Following deep changes in the nominal exchange rate, several central banks try to offset part if this oscillation intervening in the FOREX market, despite this being a non standard policy under the traditional inflation target framework. This may be due to "fear of float"[6] by policy makers that may allow exchange rate to float only inside a certain band.

Chang (2008) provide some hypothesis on why central banks in Latin America

[6] The classical reference about "fear of float" is Calvo e Reinhart (2000).

intervenes in exchange rates even though they follow an IT regime. First, if a large share of firms' debt is denominated in dollar, a sudden depreciation might cause a deep recession, preventing firms from investing. Central banks may also want to build international reserves to forearm from international liquidity shortage. Lastly, government may suffer pressures from interest groups to intervene in the exchange rate in order to be more favorable to certain sectors. An implication of these interventions in the exchange rate is presented by Edwards (2015), who finds evidence of high pass-through from American monetary policy to Latin American countries even though they adopt flexible exchange rates, and suggests that this might be because of "fear of float", making the authorities tempted to follow the international monetary policy to avoid weakening their currency.

The evidence from emerging markets suggests that their central banks may have two targets and two instruments. This is precisely the argument made by Ostry, Ghosh e Chamon (2012), which, in fact, argues that, when possible, central banks from emerging economies should use two instruments: interest rate and FOREX market intervention, even under the inflation targeting framework. The authors argue that by not intervening in the FOREX market, central banks will always have a suboptimal reaction, whether is a domestic or an international shock. Taylor rule estimations for Latin American countries (Stone, Walker e Yasui (2009), Barajas et al. (2014)) have shown that changes in the exchange rate are important when setting monetary policy. Adler e Tovar (2011) analyzes how effective is intervention in the FOREX market done by emerging economies during the period of 2004 to 2010 and concludes that it can in fact slow the process of appreciation, but this result is conditioned on the degree of capital account openness. In the VAR framework, Rohe e Hartermann (2015) analyze the effects of external disturbances on FOREX intervention for Brazil and Colombia, finding evidences that foreign exchange intervention allow the central banks to set monetary policy more independently from international events, as long as international reserve is available.

3.4.0.1 Commodity prices shock

Figure 6 shows the response of the Brazilian economy to a shock in commodity prices. We can see that the responses do not change considerably, only inflation seems to be higher during the first 6 quarters in the extended model. For the other countries there is no significant change, which can be seen in Appendix C, from figures 22 to 32.

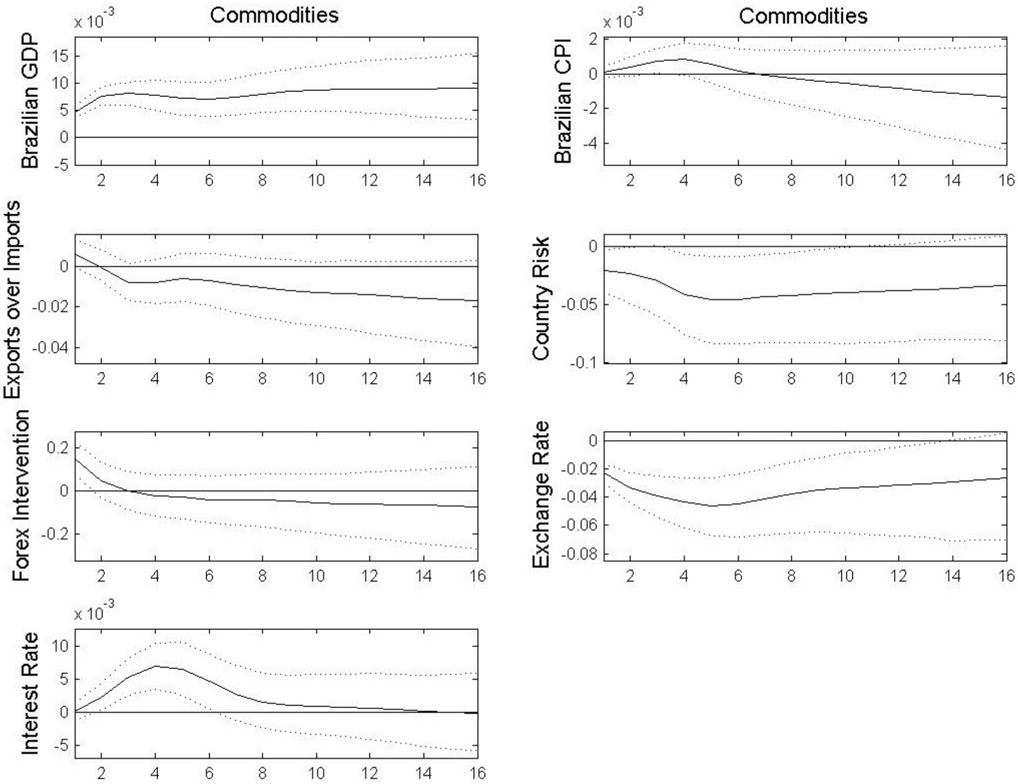

Figure 6 – Response of Brazilian variables to a commodity price shock

Several studies about emerging economies find evidences that trade balance behaves countercyclically: when the economy is growing, imports tend to rise as well, and when growth resumes, imports fall more quickly than exports. Brazil, Chile and Peru display this pattern in the trade balance, while Colombia and Mexico see their trade balance having a considerable surplus.

The response of Colombia is quite expected since it is the country with the highest share of commodity to exports in the sample. Mexico has a strong instant surplus in trade balance but soon after return to its previous path, which is quite normal given it is less dependent on commodities and has a more diversified industry. However, the response of Chile and Peru is somehow unexpected. Peru and Chile observe a strong rise in imports, yet in both countries commodity responds to more than 50% of their exports. One explanation might be that given that dependency on commodities, their income greatly increase, which augments the demand for imported goods. This might explain the behaviour of Peruvian trade balance, since their GDP increases greatly in response to the shock. On the other hand, the Chilean economy does not have a strong response of GDP and it actually starts to decrease around the $6th$ quarter after the shock.

The response of the exchange rate has not changed in the expanded model, appreciating in every country. In response to this appreciation, central banks of every country in the sample intervene in the foreign exchange market, buying dollars in order to control this appreciation. Therefore, there is evidence that their central banks has a sort of target for the exchange rate, which might be because of a fear of commodity currency and its effects.

3.4.0.2 Uncertainty shock

The response of the variables to an uncertainty shock does not considerably change in the extended model as can be seen in figure 7. We can see that the trade balance in Brazil, Chile and Peru is improved. There might be two reasons to explain this improvement. First, all economies observe a strong decrease in output, which leads to a lower demand for imported goods. Second, the exchange rate strongly depreciates, which is good for exports and bad for imports, reinforcing the dynamics of lower demand for imported goods.

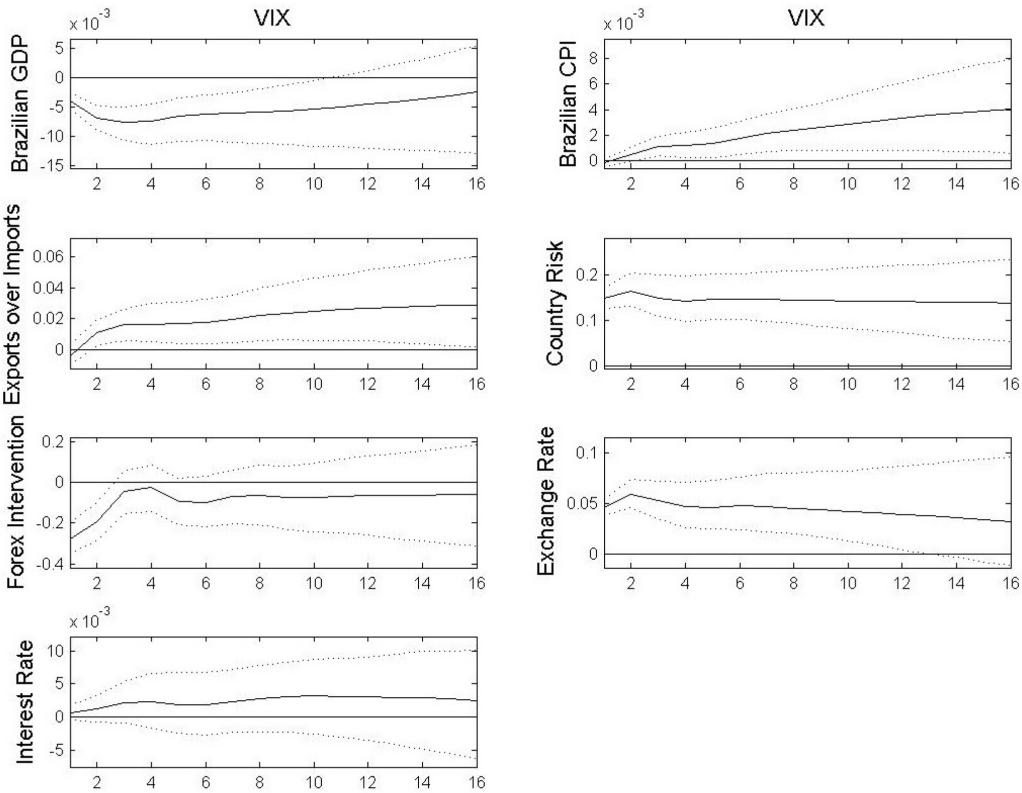

Figure 7 – Response of Brazilian variables to a VIX shock

The Brazilian and Peruvian case seems to be explained mostly by the first reason given the strong decrease in output in this two countries. If there is an increase in exports, the depressive effect of the shock more than compensate it. As pointed before, the response of Chile has been quite puzzling and the improvement in the trade balance might explain it. Chile is by far the country with more economic openness in the sample as shown by figure 5 and this might explain why the Chilean economy observes a small decrease in output and why it reverts one year and half after the shock. The literature of uncertainty shocks documents that these shocks are short lived; uncertainty rises for a while but soon after it returns to normal. This is why in developed economies the effect is a strong drop in economic activity followed by a strong rebound. This might be the case for Chile, given their economic openness, they are able to revert the depressive situation as soon as the international market returns to normal. However, if this is the case, we should have seen a similar behaviour in the Mexican economy, which does not occur, therefore, there might be other factors that account for this response of the Chilean economy, like better integrated financial markets, which this work can not assess.

On the other hand, the trade balance in both Mexico and Colombia indicates a rise in import goods relative to exports. Both countries display a strong reaction at impact, returning to normality since then. This might be due to a worsening in international conditions, which reduce the demand for goods exported by emerging markets. The fact that uncertainty shocks are often short lived might explain their behavior of returning to normality.

The exchange rate response does not change in the extended model, depreciating in every country, as expected. This depreciation lead the central banks of all countries in the sample to intervene in the foreign exchange market by selling dollars, in a tentative to control the depreciation. Once again, there is evidence that the central banks are not comfortable to let their exchange rates to freely float, indicating that might be an exchange rate target as well, as suggested by Ostry, Ghosh e Chamon (2012) and Rohe e Hartermann (2015).

3.4.0.3 Summary

Despite the introduction of two additional variables in the model, the response of the variables of the baseline model did not change, therefore, we can not affirm that foreign exchange intervention is being effective in these countries, or, at least, is relevant to explain business cycles fluctuations in emerging economies. The exchange rate do not seem to be affected at all by these interventions, and the original shock seems to be the main driver behind its response. The main aggregate variables do not change as well. Inflation increases in response to a higher economic uncertainty much because of the considerable depreciation of the exchange rate, however, the interventions in the forex market does not help to mitigate the pass-through because the exchange rate does not seem to respond to these interventions.

Although the inclusion of the trade balance helps us to better understand the effects of such shocks, it does not prove to be essential to explain the dynamics of these shocks. In fact, the puzzling response of Chile to a commodity shock gets even more confusing when we see the response of the trade balance. Chile is the most open country in the sample and commodity exports account for more than 50% of its total exports, and, still, Chilean GDP has a small rise and start to decline in the $4th$ quarter after the shock, which is not expected at all. When we look at the trade balance we see that imports gain relative importance over exports and there is no piece of evidence to support this. It would be expected to these countries to observe a rise in imports because of the income effect of such shock, however, the increase in Chile GDP is not that big to explain this behaviour of the trade balance, and given the trade structure of Chile, we would expect at least an improvement in export at time zero after the shock, which we do not observe.

3.4.0.4 The relative importance of external shocks in the extended model

Table 6, in the Appendix, show the forecast error variance decomposition of the extended model when hit by commodity prices and uncertainty shocks. Overall, the results has not changed substantially. As expected, trade balance is highly affected by these two shocks. In Colombia an uncertainty shock explain 45% of the variability of the trade balance in the first year after the shock, while in Chile, a commodity prices shock explain more than 70% of the trade balance variability. This is expected since Chile has a major dependency on commodity export.

These shocks also explain a great share of the variability in foreign exchange interventions, which was expected, since these two shocks are the ones most responsible for volatility in the exchange rate. With the exception of Peru, uncertainty shocks matter more than commodity shocks in explaining the interventions in the exchange rate. This suggest that capital flows in response to changes in uncertainty might matter more to central banks than the ones generated by commodity prices variations. In Peru, commodity shocks explain more the variability in the forex intervention, which is in line with the findings by Tashu (2015) who argue that forex intervention done by the Peruvian central banks might have been effective in mitigate the effects of commodity currency in Peru.

4 Concluding remarks

This master thesis investigate the impacts of international shocks in emerging economies by estimating a block-exogenous Bayesian Structural Vector Autoregression for Brazil, Chile, Colombia, Mexico and Peru, and the challenges these shocks may impose to policymaking in these countries. Since all economies in the sample are net exporters of commodities, the main goal is to assess how different commodity prices oscillations affect these economies, and to achieve that it is considered two shocks, a pure commodity prices shock and a global uncertainty shock, used here as an indirect source of commodity prices fluctuations, and measured by the implied volatility of the S&P 500 index, following Bloom (2009) and others.

The main result indicates that is extremely relevant, to the point of view of the policy maker, to correctly identify the source of fluctuation in commodity prices. When considering a pure commodity shock, we observe that four out of five economies analyzed have a strong positive reaction in both GDP and CPI, observing a decrease in country risk and an exchange rate appreciation. Even though these countries might suffer from commodity currency effects, the spending effect of the export sector seems to dominate the pass-through of the exchange rate, generating considerable inflation. In this case, we observe that central banks increase their monetary policy interest rate to stabilize the expansive effect of the shock.

On the other hand, uncertainty shock has more intense impacts on emerging economies than a pure commodity shock. A reduction in global economic uncertainty is mostly transmitted through financial channels, lowering the country risk by a factor 7.5 times higher than in a pure commodity shock, generating a stronger exchange rate appreciation. In this case, although it has a positive impact on GDP, we observe that inflation decrease, because the exchange rate pass-through seems to dominate the other expansive effects generated throughout this economies.

Therefore, we observe that an increase in commodity prices has opposite inflationary effects in net commodity exporters emerging economies, depending on the source of its fluctuation. This impose serious challenges to monetary policy in these economies, because if the source of the commodity price fluctuation is not correctly identified, the central bank might intensify the destabilizing effects of such shocks. This result challenges the argument that all commodity prices fluctuations, regardless their source, should be considered as an exogeneous supply shock, as defended by Blanchard e Gali (2007). However, studies like Kilian (2009), Bodenstein, Guerrieri e Kilian (2012) and Charnavoki e Dolado (2014), questions such argument and provide evidences that not all commodity prices fluctuation is alike, that the original source of the fluctuation matters.

By performing forecast error variance decomposition, it can be seen that both uncertainty and commodity prices shocks account for most of the variability of the domestic variables, suggesting that external disturbances are the main drivers of Latin American business cycles, with uncertainty shocks explaining 30% of GDP variability and more than 20% of CPI changes, while commodity prices shocks explaining a large share of both GDP and CPI as well, accounting for 44.5% of Brazilian GDP and 76.5% of Chilean CPI. Country risks are almost completely explained by both shocks, which suggests that this might be the main channel of transmission. The fact that both shocks are so important in explaining business cycles in Latin America posits additional challenges for policymakers, since the adoption of good economic policies might not be sufficient to keep the economy stable.

Another characteristic that these emerging economies analyzed here share is that all of them set their monetary policy under the inflation targeting framework, however, their central banks are well known to perform systematic interventions in the foreign exchange market to control exchange rate volatility. Both shocks studied here have deep impact on exchange rate volatility, therefore the model was expanded to take into account intervention in the foreign exchange market. The evidence suggest that the central banks of these economies are actively trying to set an exchange rate level, fighting excessive appreciation or depreciation. This result, together with evidence gathered by other studies like Ostry, Ghosh e Chamon (2012), suggest that Latin American countries adopt an exchange rate target as well, limiting their fluctuation to a predetermined band. However, the results of the baseline model were robust to the inclusion of this variable, suggesting that forex intervention has not been effective in smoothing the volatility of these economies.

It would be fruitful to formally incorporate into the model the source of the external shock, as proposed by Kilian (2009) as well as to expand the model of Bodenstein, Guerrieri e Kilian (2012) to deal with commodity exporter economies in a structural theoretical based model. Additionally, international monetary policy should be analyzed as well. However, there are few issues that must be dealt with, specially the correctly identification of U.S. monetary policy together with commodity and uncertainty shocks. An alternative would be to extract the U.S. monetary policy shock from a global model and feed it into the domestic model. These are planned for future research.

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Appendix

APPENDIX A – Impulse response functions - Baseline model

A.1 Brazil

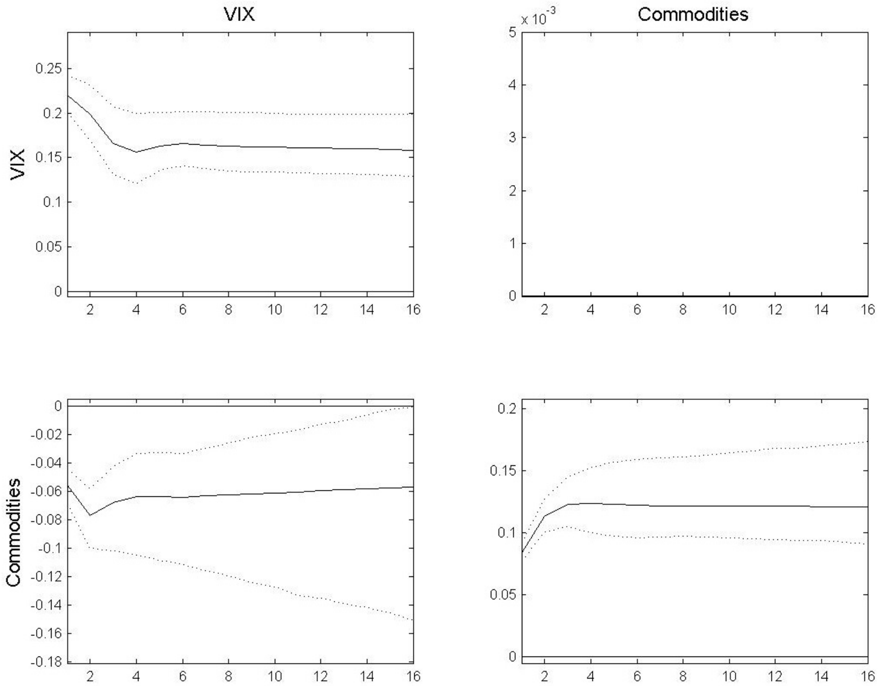

Figure 8 – Response of international variables

A.2 Chile

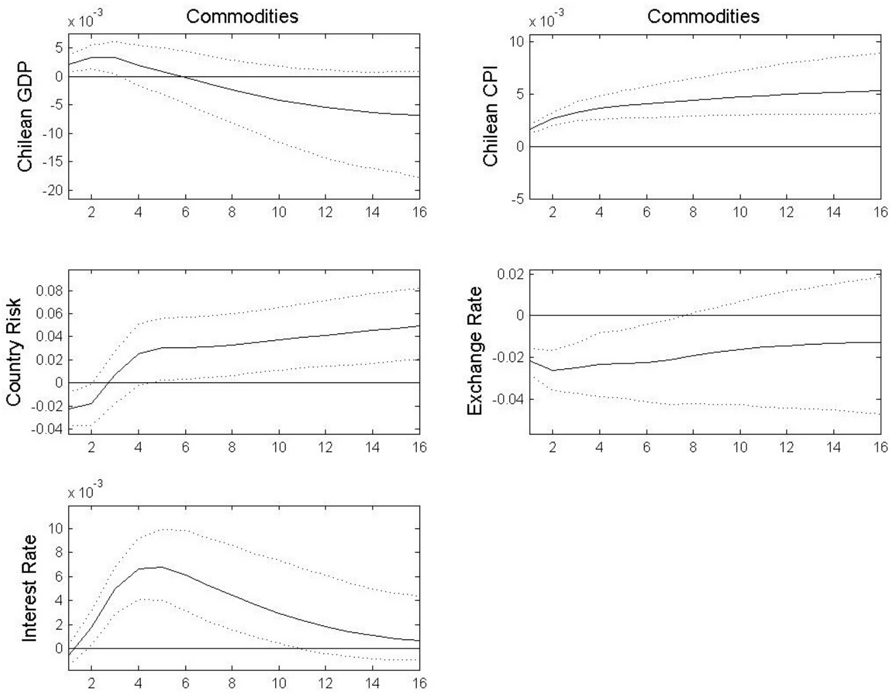

Figure 9 – Response of Chilean variables to a commodity price shock

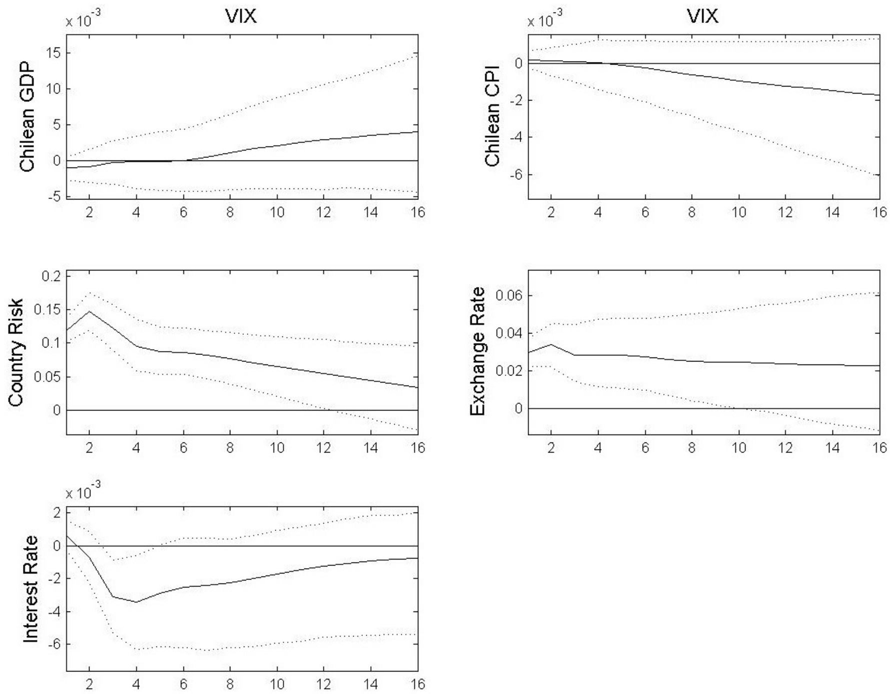

Figure 10 – Response of Chilean variables to a VIX shock

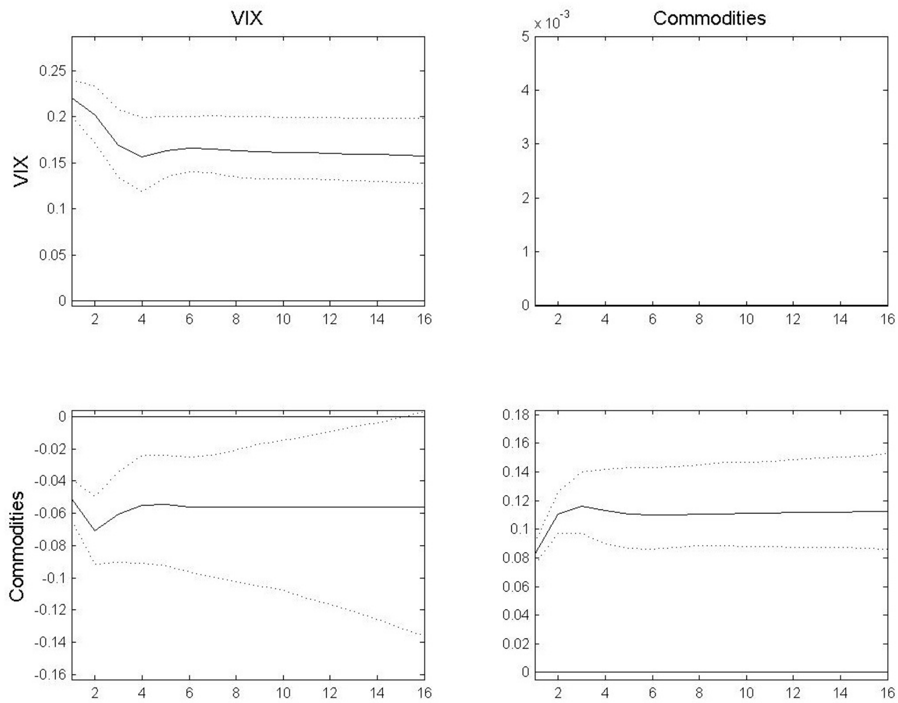

Figure 11 – Response of international variables

A.3 Colombia

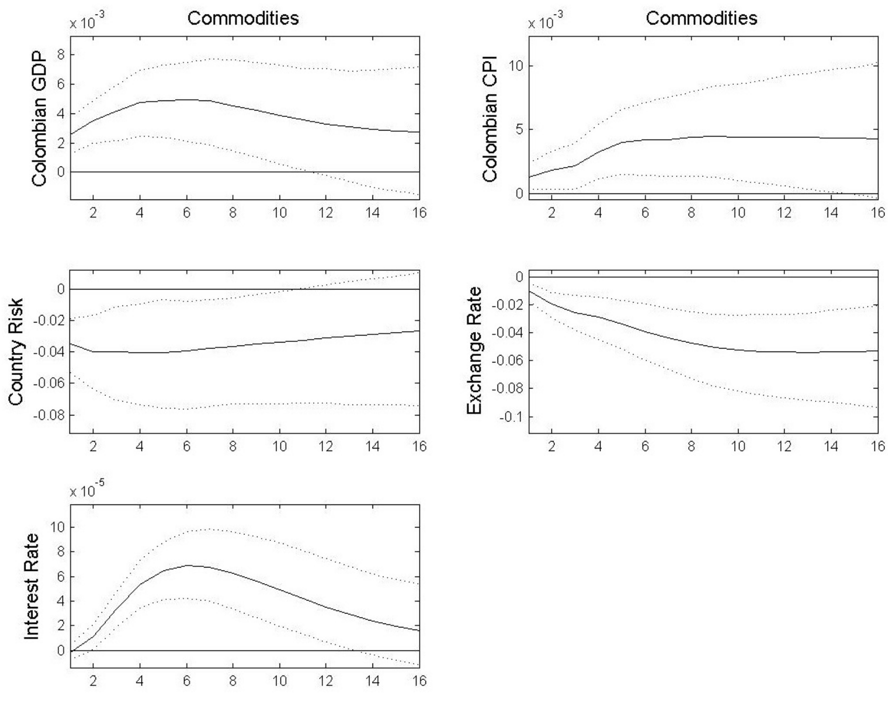

Figure 12 – Response of Colombian variables to a commodity price shock

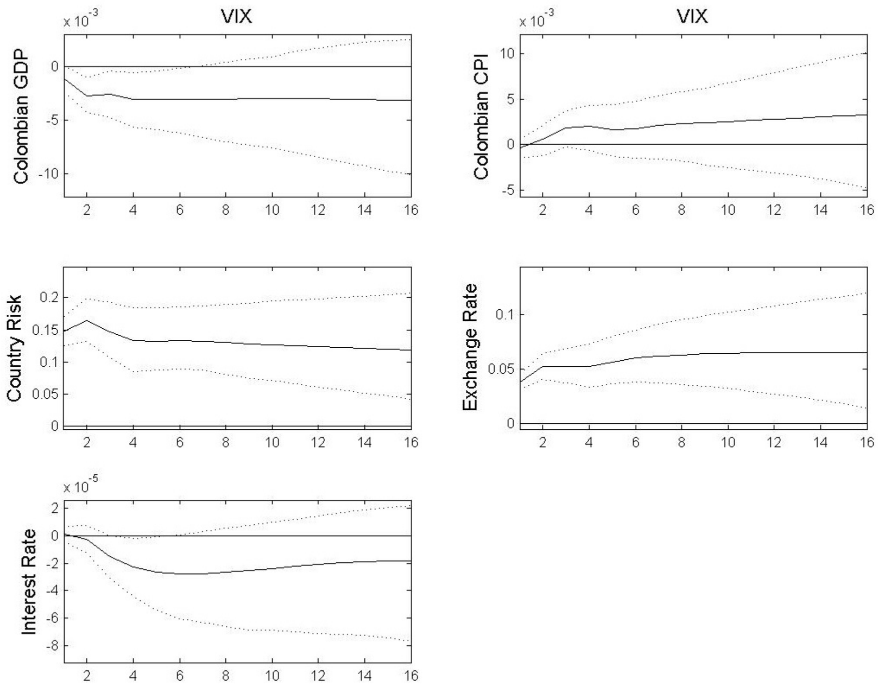

Figure 13 – Response of Colombian variables to a VIX shock

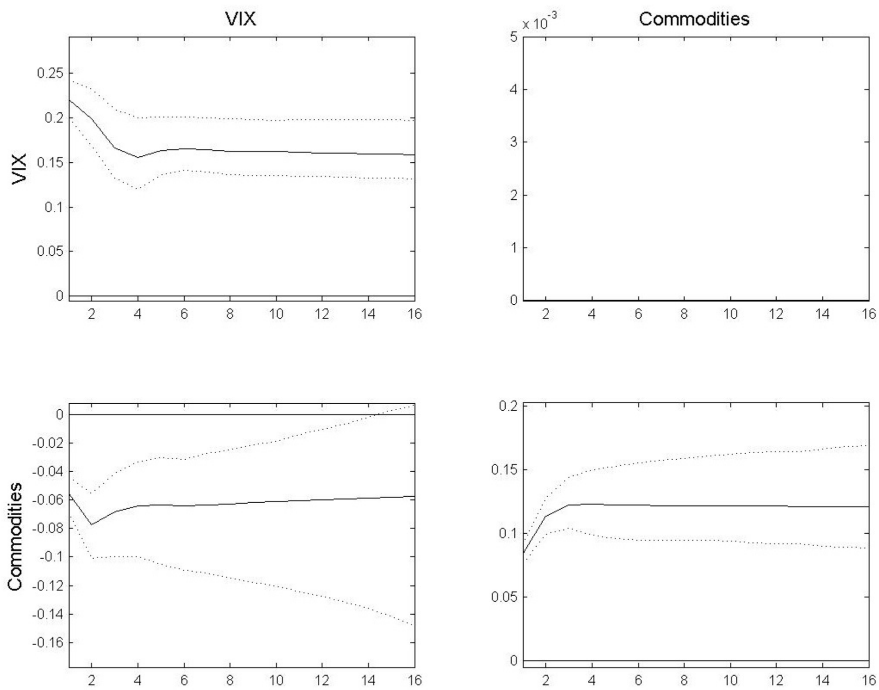

Figure 14 – Response of international variables

A.4 Mexico

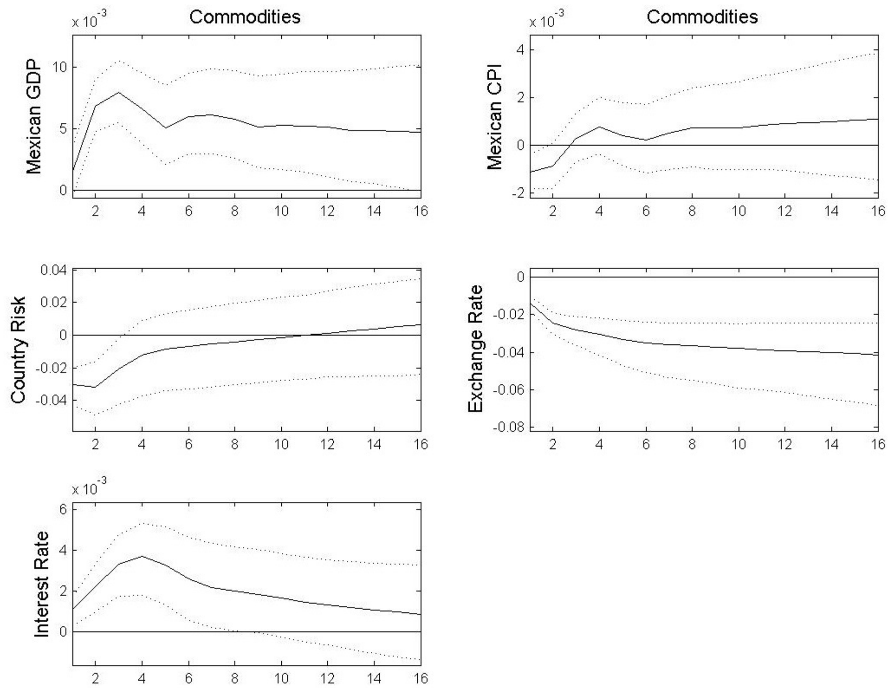

Figure 15 – Response of Mexican variables to a commodity price shock

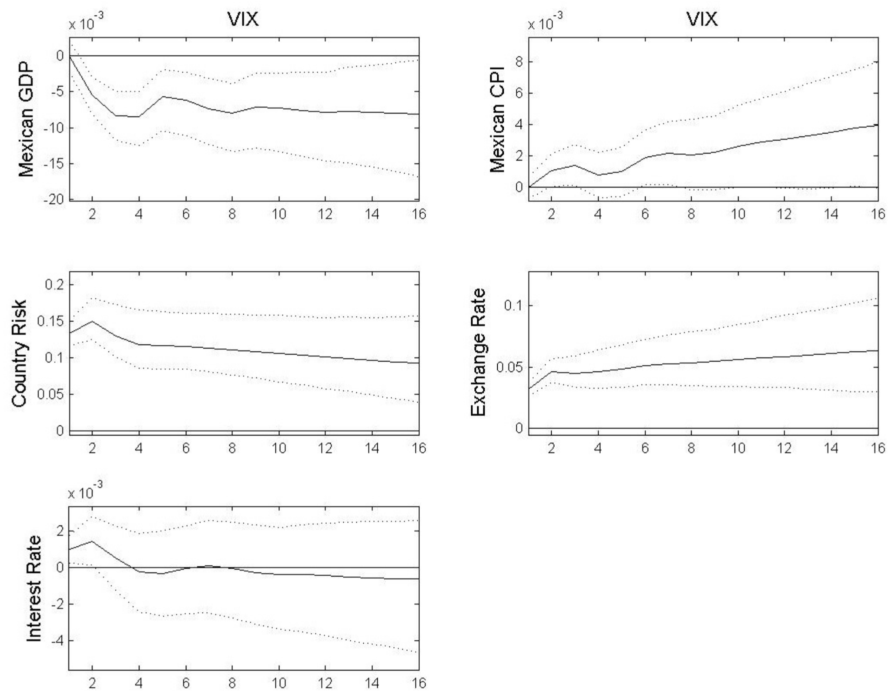

Figure 16 – Response of Mexican variables to a VIX shock

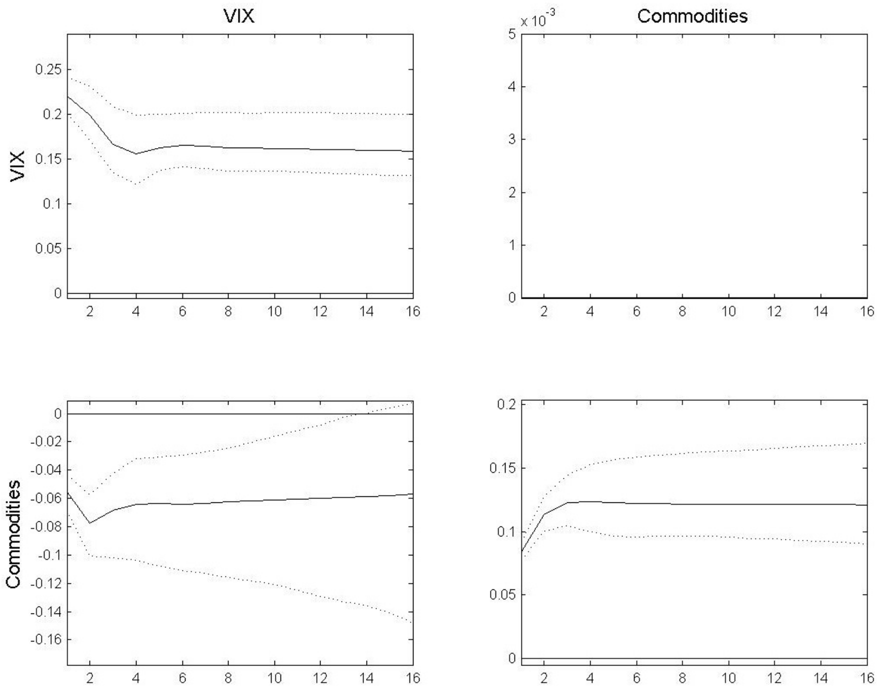

Figure 17 – Response of international variables

A.5 Peru

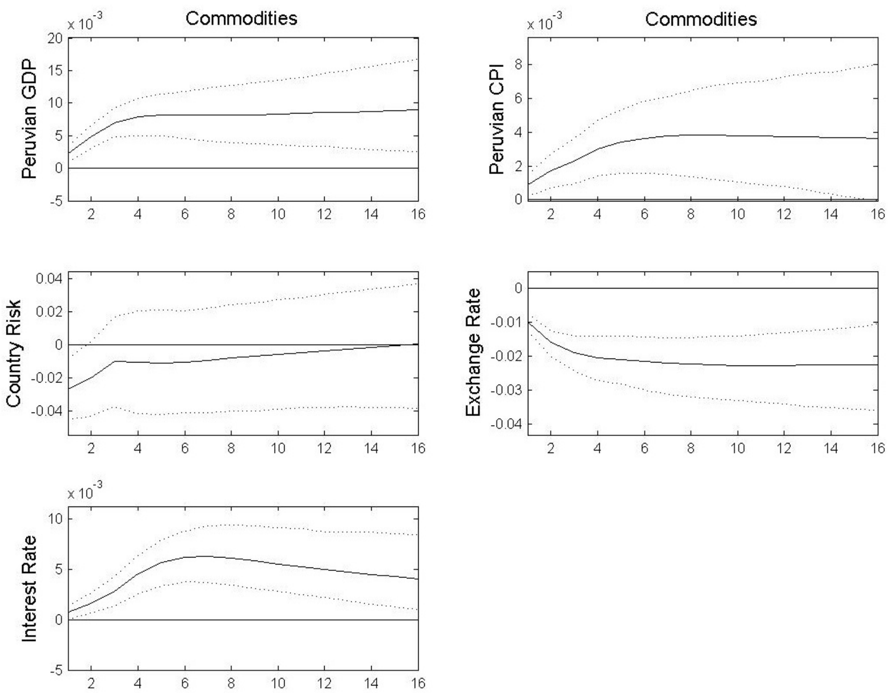

Figure 18 – Response of Peruvian variables to a commodity price shock

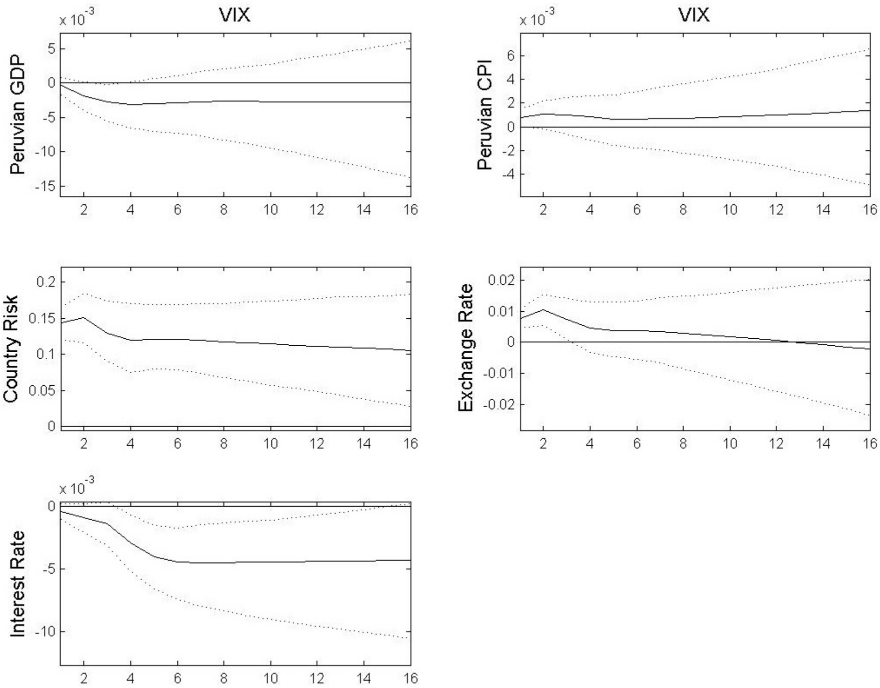

Figure 19 – Response of Peruvian variables to a VIX shock

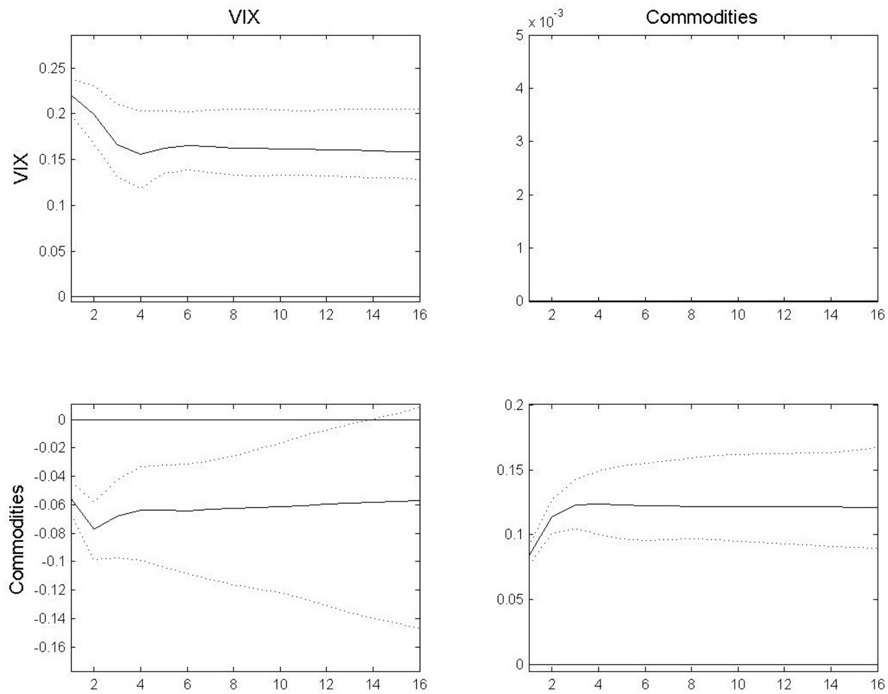

Figure 20 – Response of international variables

APPENDIX B – Forecast Error Variance Decomposition

B.1 Baseline model

Table 5 – Forecast error variance decomposition of international shocks - Baseline model

Country	Horizon	VIX	PCOM	VIX	PCOM	VIX	PCOM	VIX	PCOM	VIX	PCOM
		GDP		CPI		EMBI		EXR		INTR	
Brazil	1-4	26.50%	44.50%	25.25%	5.50%	52.00%	8.25%	39.00%	24.25%	8.00%	0.75%
	5-8	25.50%	47.25%	40.00%	21.00%	45.50%	27.25%	25.25%	45.25%	17.25%	32.00%
	9-12	18.50%	58.00%	38.00%	45.00%	41.00%	37.50%	25.50%	53.75%	16.00%	66.25%
	13-16	14.00%	65.50%	36.75%	53.75%	39.00%	42.50%	23.50%	64.25%	16.25%	70.25%
Chile	1-4	28.75%	17.25%	2.75%	76.5%	73.5%	3.25%	45.50%	39.75%	5.75%	12.00%
	5-8	59.00%	26.75%	20.75%	63.5%	75.25%	4.25%	41.75%	47.75%	16.50%	22.25%
	9-12	53.00%	40.25%	32.75%	51.75%	71.25%	6.50%	35.25%	55.25%	10.00%	35.75%
	13-16	48.00%	44.25%	38.75%	44.50%	69.50%	9.50%	33.25%	57.50%	17.25%	28.00%
Colombia	1-4	16.00%	26.00%	46.00%	1.50%	59.50%	13.50%	46.25%	9.25%	1.75%	41.00%
	5-8	52.25%	29.00%	50.25%	6.25%	55.00%	28.00%	27.25%	45.50%	0.75%	66.25%
	9-12	67.75%	20.00%	35.25%	31.75%	50.75%	35.50%	15.50%	73.25%	2.75%	62.25%
	13-16	59.25%	29.25%	18.75%	65.25%	48.50%	39.25%	14.25%	77.75%	4.25%	74.50%
Mexico	1-4	29.25%	11.00%	22.00%	6.75%	70.50%	6.50%	61.75%	22.50%	23.25%	11.50%
	5-8	48.75%	12.50%	22.50%	22.75%	73.00%	6.00%	47.25%	39.00%	17.50%	13.50%
	9-12	50.75%	11.50%	13.25%	47.25%	73.00%	6.00%	44.25%	40.00%	20.00%	15.50%
	13-16	48.00%	15.50%	7.50%	67.25%	73.00%	6.00%	38.00%	47.00%	23.50%	25.75%
Peru	1-4	2.00%	21.00%	5.25%	1.5%	55.5%	8.50%	12.50%	51.75%	17.75%	13.50%
	5-8	5.50%	41.25%	11.75%	16.50%	56.00%	20.00%	7.25%	72.50%	44.00%	23.75%
	9-12	7.75%	47.00%	8.25%	41.50%	52.00%	29.25%	5.75%	76.50%	48.25%	19.25%
	13-16	7.00%	45.50%	5.75%	46.50%	50.00%	33.00%	5.00%	76.25%	51.50%	15.25%

B.2 Extended model

Table 6 – Forecast error variance decomposition of international shocks - Extended model

Country	Horizon	VIX	PCOM	VIX	PCOM	VIX	PCOM	VIX	PCOM	VIX	PCOM	VIX	PCOM	VIX	PCOM
		GDP		CPI		XOM		EMBI		FX		EXR		INTR	
Brazil	1–4	17.25%	43.00%	10.75%	12.00%	3.00%	3.25%	52.50%	7.50%	19.25%	12.00%	32.75%	14.65%	1.75%	7.75%
	5–8	14.00%	28.75%	30.50%	8.25%	9.25%	9.25%	47.00%	24.75%	19.75%	14.25%	23.75%	27.00%	6.00%	14.25%
	8–12	15.25%	21.50%	39.00%	21.75%	21.50%	16.25%	43.00%	34.00%	19.50%	16.00%	24.25%	32.50%	8.00%	30.50%
	12–16	30.25%	23.50%	40.75%	35.25%	27.50%	19.50%	40.75%	38.50%	19.75%	16.00%	24.50%	42.25%	8.25%	28.50%
Chile	1–4	55.25%	16.75%	6.75%	83.75%	15.50%	57.50%	73.75%	3.50%	22.50%	12.00%	54.75%	33.00%	11.50%	36.25%
	5–8	51.00%	44.25%	19.75%	74.25%	14.00%	72.50%	77.50%	4.00%	31.25%	25.75%	50.25%	39.00%	21.50%	51.00%
	8–12	40.00%	56.25%	23.00%	70.50%	16.75%	72.00%	75.00%	5.75%	30.75%	30.75%	46.50%	37.50%	23.50%	41.00%
	12–16	35.75%	60.00%	27.50%	66.50%	17.50%	71.00%	73.00%	8.50%	33.25%	31.00%	35.25%	46.75%	20.50%	38.25%
Colombia	1–4	20.25%	40.75%	19.00%	25.25%	45.00%	16.75%	59.00%	13.50%	44.25%	1.00%	60.25%	8.75%	0.00%	73.50%
	5–8	42.00%	43.00%	18.75%	50.00%	31.00%	22.25%	57.50%	23.75%	34.50%	6.75%	44.00%	10.50%	0.50%	84.25%
	8–12	65.50%	23.50%	11.50%	47.00%	21.25%	26.50%	56.00%	29.75%	21.75%	38.75%	35.50%	13.75%	15.00%	65.00%
	12–16	69.50%	14.50%	20.75%	39.25%	19.00%	24.75%	55.25%	32.25%	17.00%	42.75%	31.00%	17.25%	34.50%	42.50%
Mexico	1–4	9.00%	22.50%	32.75%	5.00%	28.75%	35.25%	71.50%	5.50%	30.75%	10.50%	66.25%	21.25%	25.25%	13.25%
	5–8	4.25%	16.50%	38.25%	10.50%	32.25%	33.00%	73.00%	5.00%	28.50%	11.50%	49.75%	33.25%	29.00%	10.50%
	8–12	15.75%	12.50%	22.00%	36.00%	31.50%	36.75%	72.00%	5.00%	30.75%	13.50%	49.00%	25.75%	44.00%	10.00%
	12–16	34.25%	27.50%	15.75%	62.00%	37.50%	29.50%	71.50%	5.00%	33.50%	12.75%	37.50%	32.25%	50.50%	23.00%
Peru	1–4	1.25%	52.00%	16.25%	0.50%	8.75%	12.25%	51.00%	8.00%	2.75%	31.00%	14.25%	46.00%	3.50%	23.00%
	5–8	1.00%	65.75%	33.00%	9.75%	14.00%	21.75%	53.75%	16.75%	2.75%	26.25%	9.50%	63.50%	2.00%	16.50%
	8–12	6.50%	32.25%	27.50%	34.75%	15.75%	18.50%	50.50%	26.25%	5.00%	24.25%	8.00%	56.75%	3.50%	25.00%
	12–16	12.00%	33.00%	21.75%	48.50%	15.00%	27.00%	49.25%	30.00%	7.50%	22.50%	8.00%	53.25%	8.75%	29.75%

APPENDIX C – Impulse response functions - Extended model

C.1 Brazil

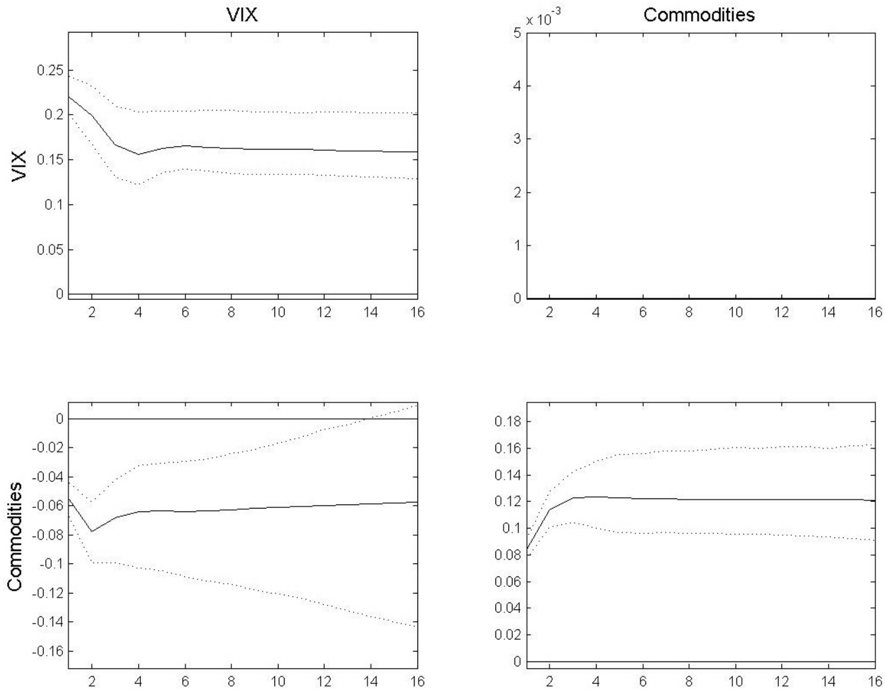

Figure 21 – Response of international variables

C.2 Chile

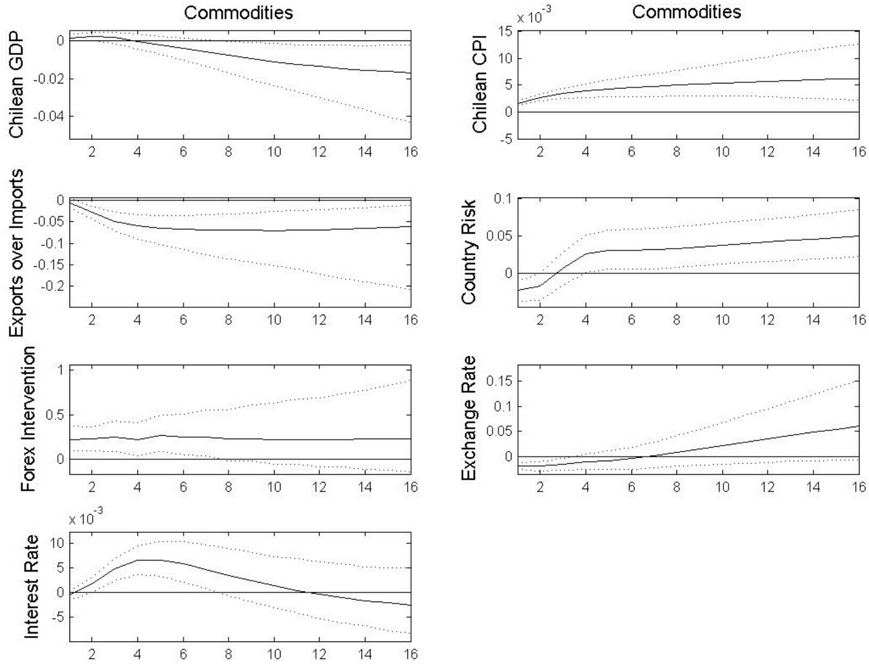

Figure 22 – Response of Chilean variables to a commodity price shock

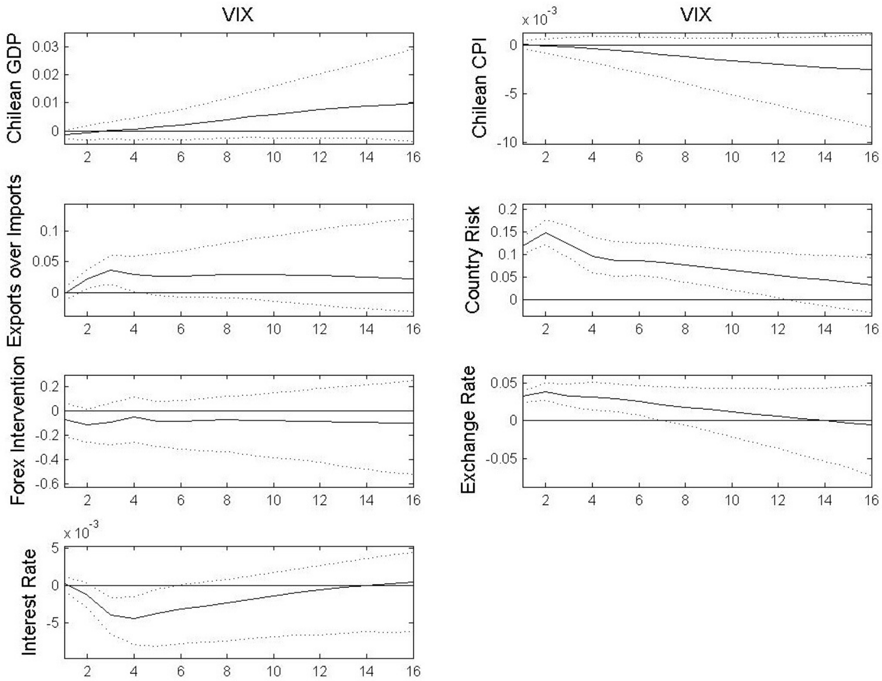

Figure 23 – Response of Chilean variables to a VIX shock

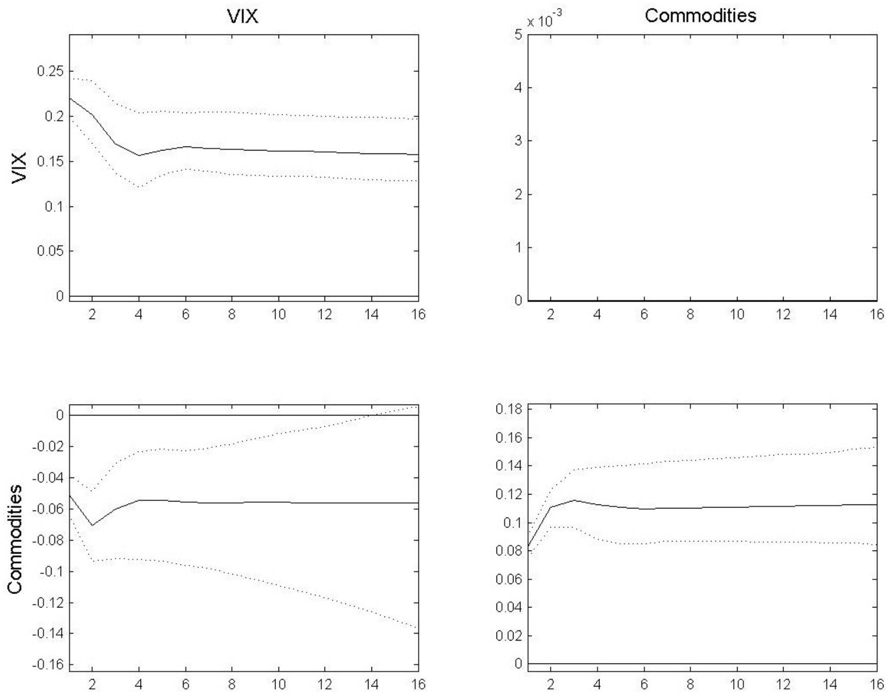

Figure 24 – Response of international variables

C.3 Colombia

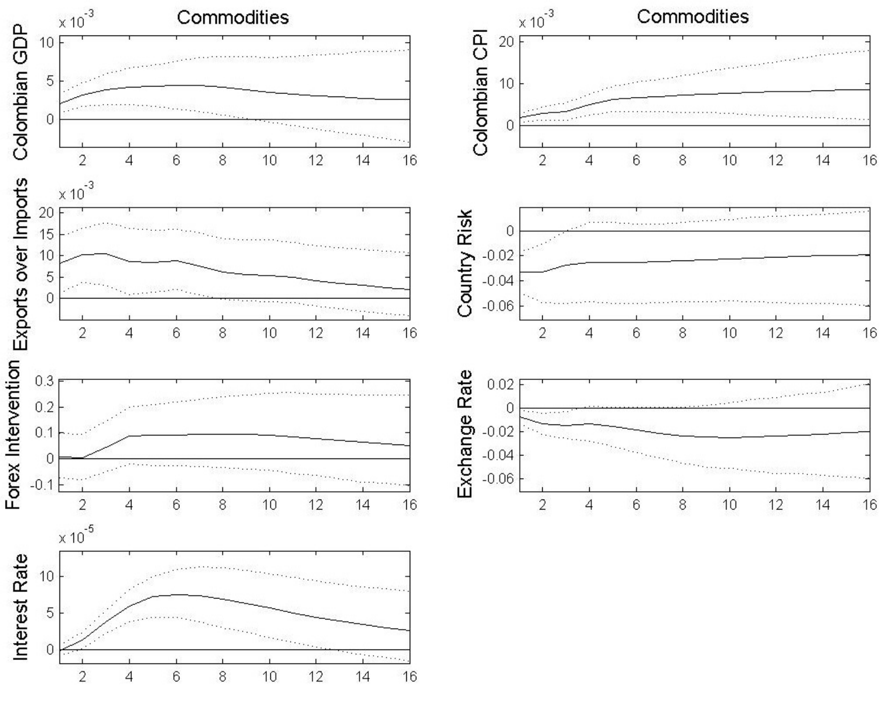

Figure 25 – Response of Colombian variables to a commodity price shock

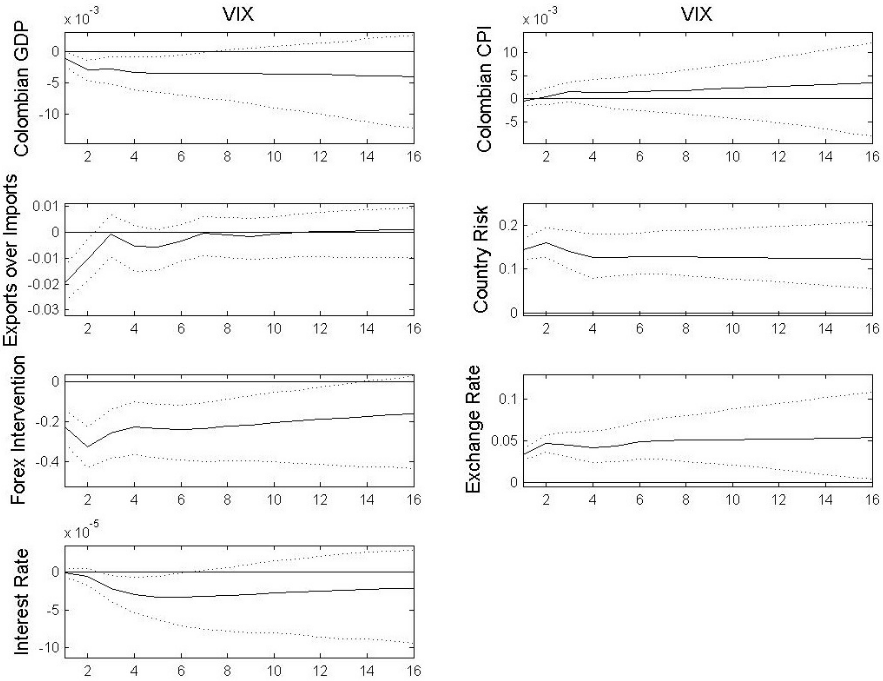

Figure 26 – Response of Colombian variables to a VIX shock

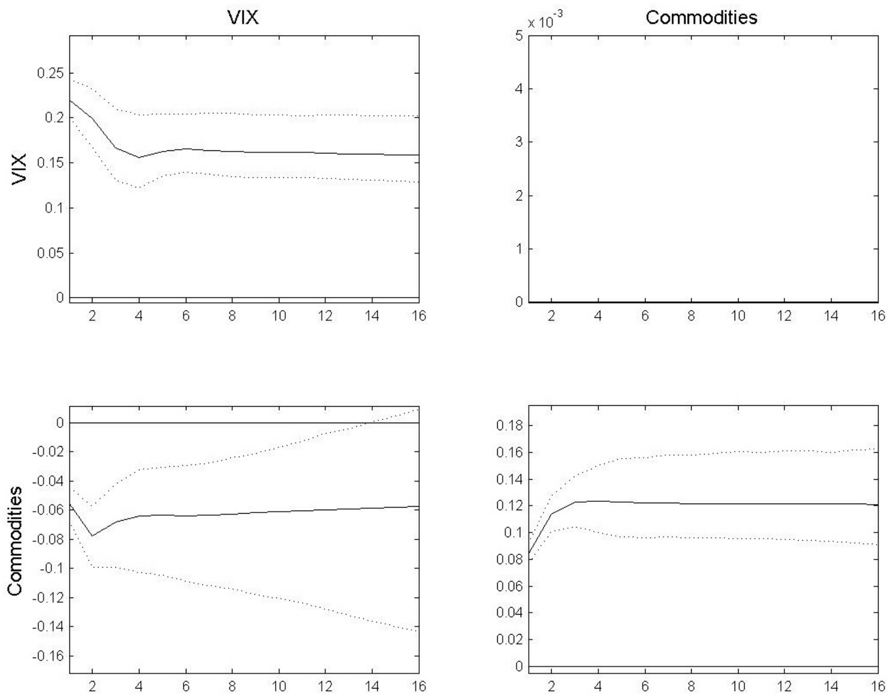

Figure 27 – Response of international variables

C.4 Mexico

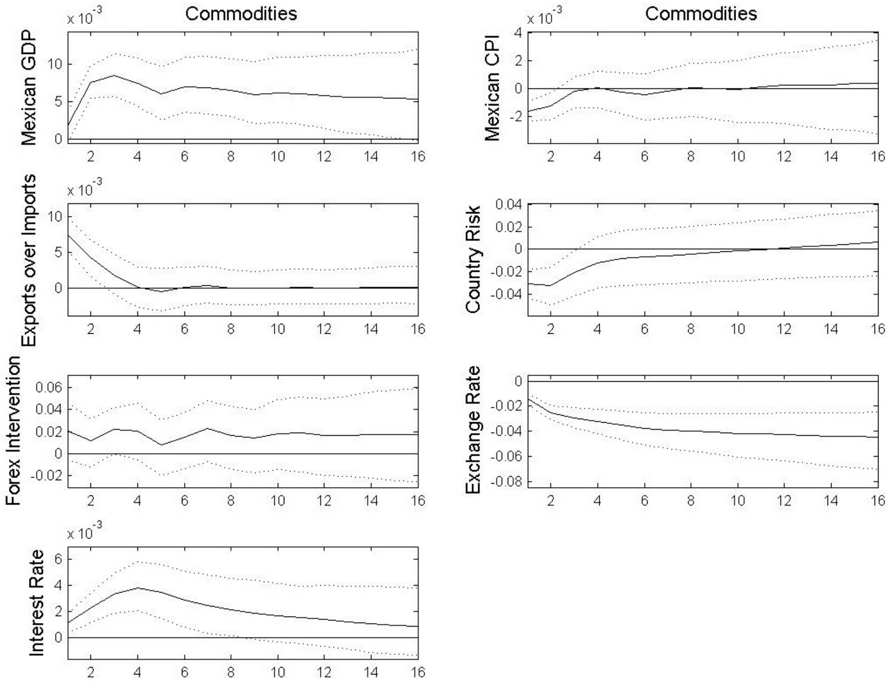

Figure 28 – Response of Mexican variables to a commodity price shock

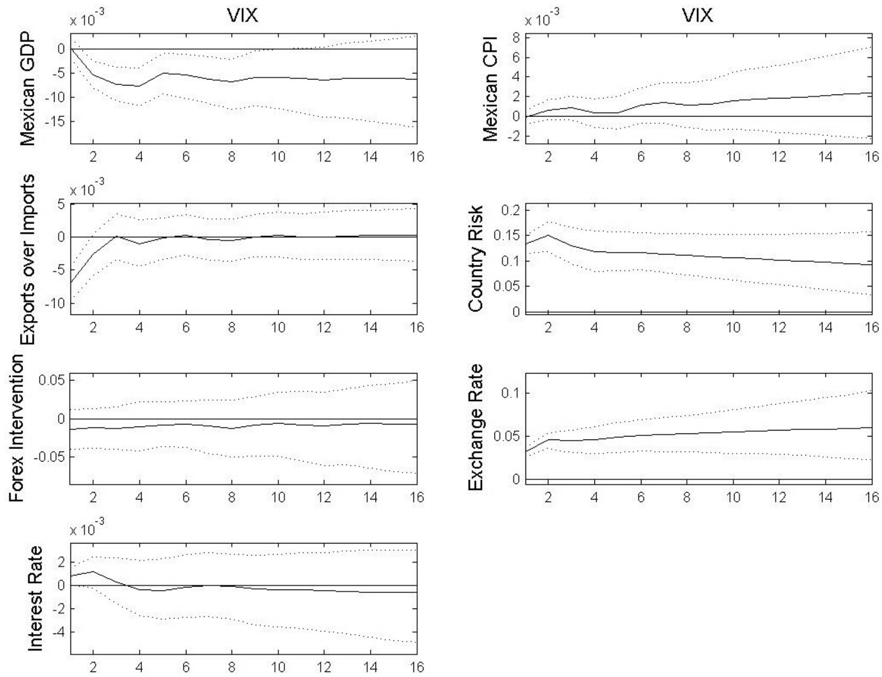

Figure 29 – Response of Mexican variables to a VIX shock

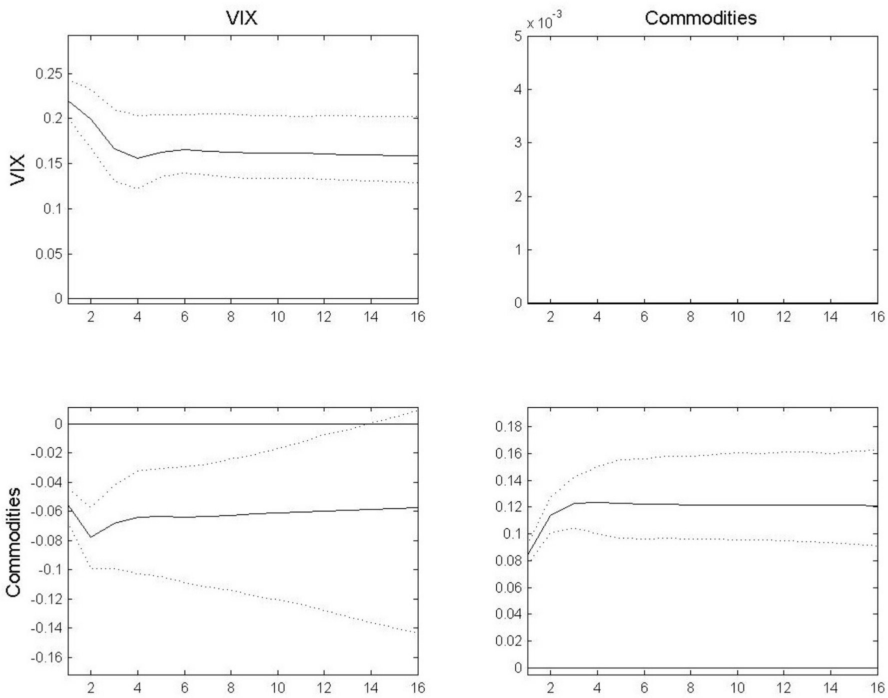

Figure 30 – Response of international variables

C.5 Peru

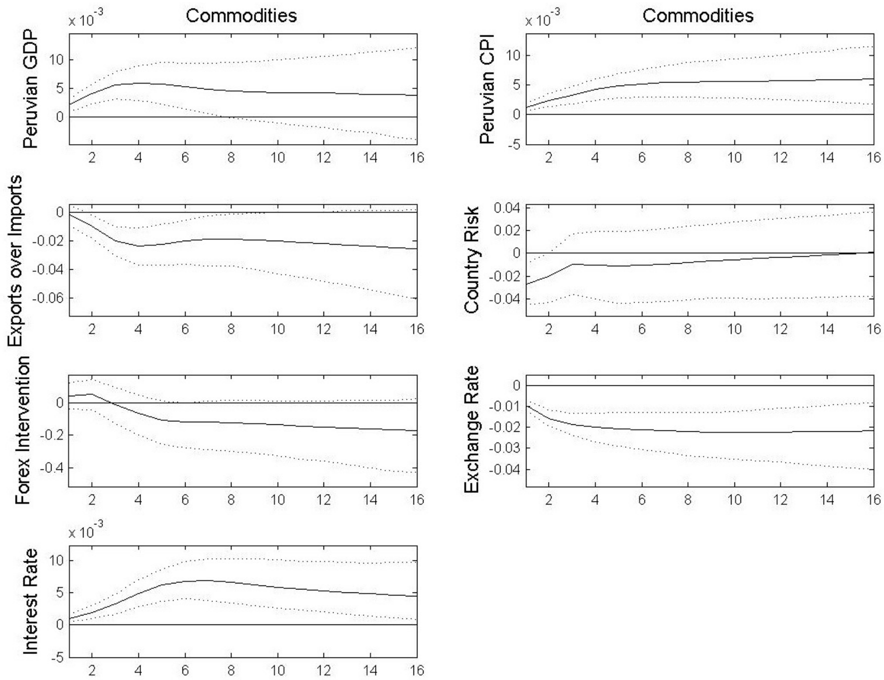

Figure 31 – Response of Peruvian variables to a commodity price shock

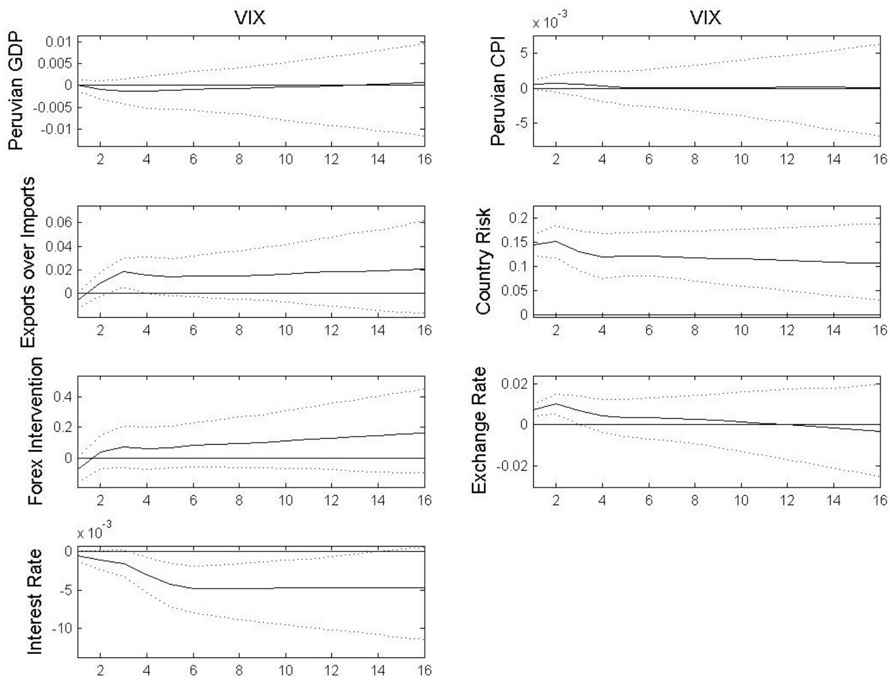

Figure 32 – Response of Peruvian variables to a VIX shock

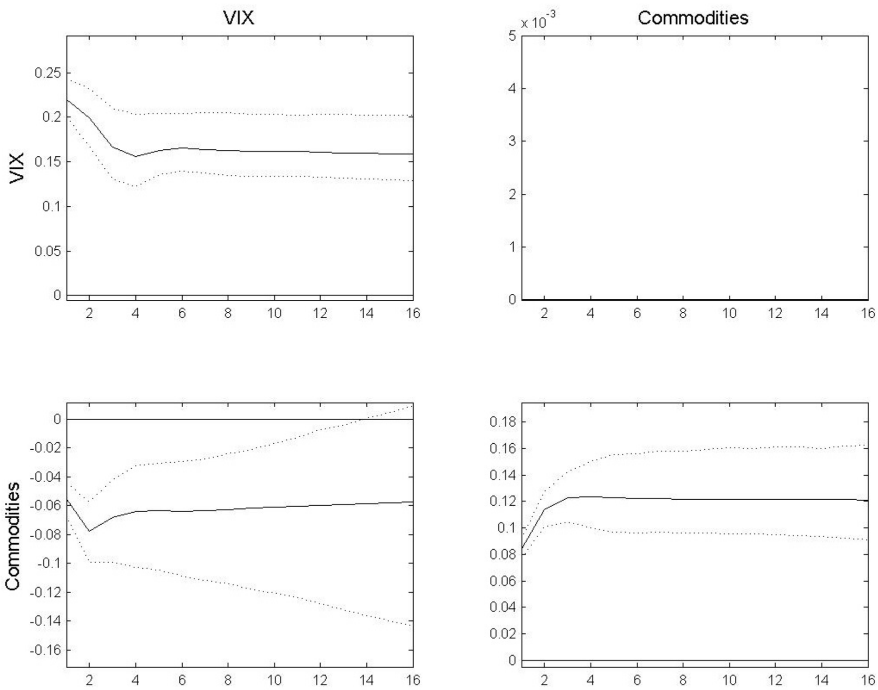

Figure 33 – Response of international variables

APPENDIX D – Impulse response functions - Robustness check

Here I present the impulse responses of the baseline model with different hypothesis. The main model was estimated assuming that the VIX equation was an AR(4) process and country risk equation only had regressors of country risk, VIX and commodity prices.

Section D.1 shows the IRFs of the model estimated assuming that VIX and PCOM can react to each other, while I keep country risk blocked as it was in the main model. Section D.2 shows the IRFs of the model estimated assuming that VIX and PCOM can react to each other and country risk is not blocked, in other words, country risk equation has regressors of every variables. Section D.3 shows the IRFs of the model estimated assuming that VIX equations follows an AR(4) process and country risk is not blocked.

D.1 VIX responding to commodities

D.1.1 Brazil

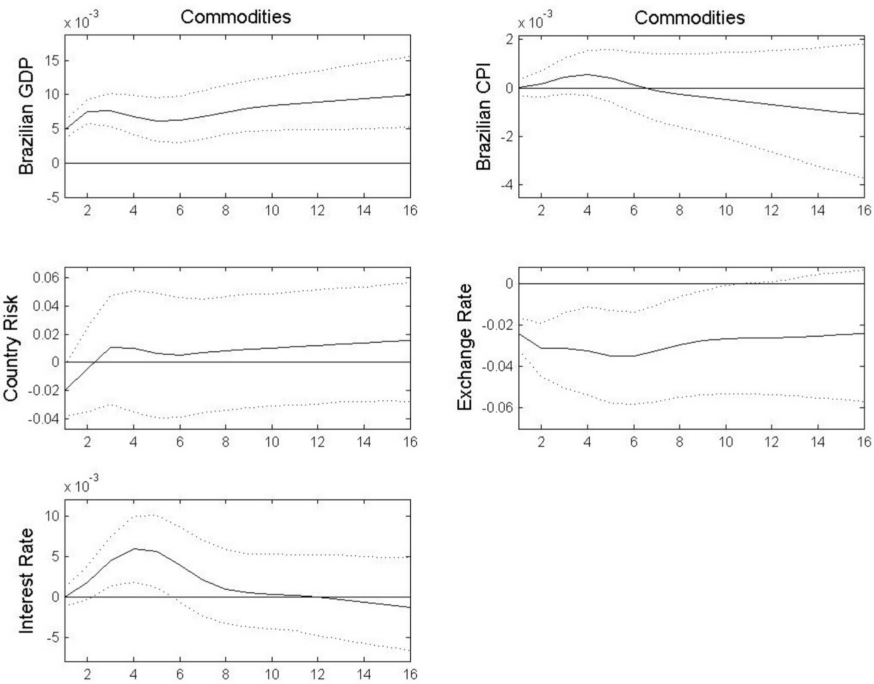

Figure 34 – Response of Brazilian variables to a commodity price shock

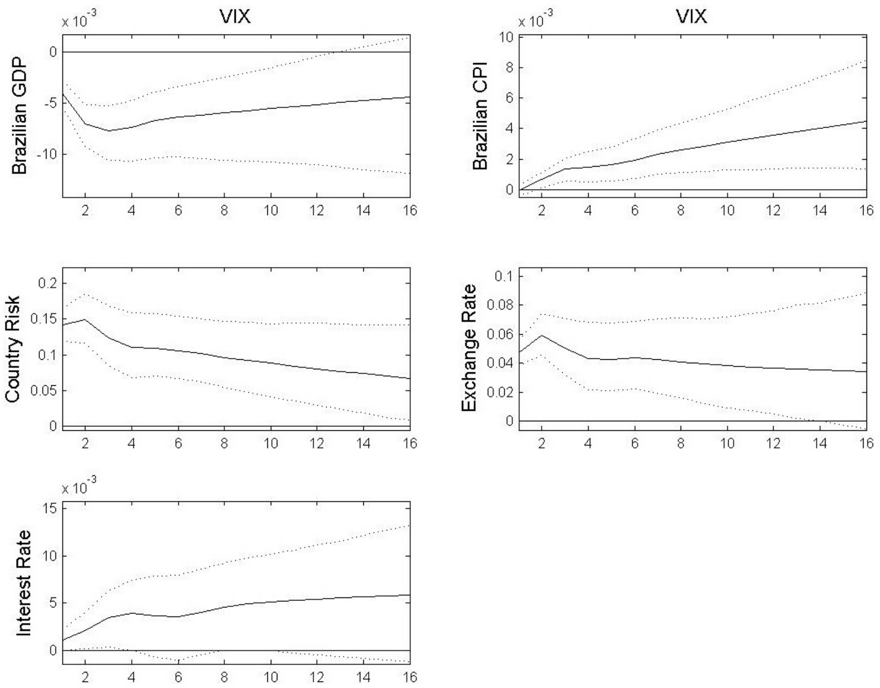

Figure 35 – Response of Brazilian variables to a VIX shock

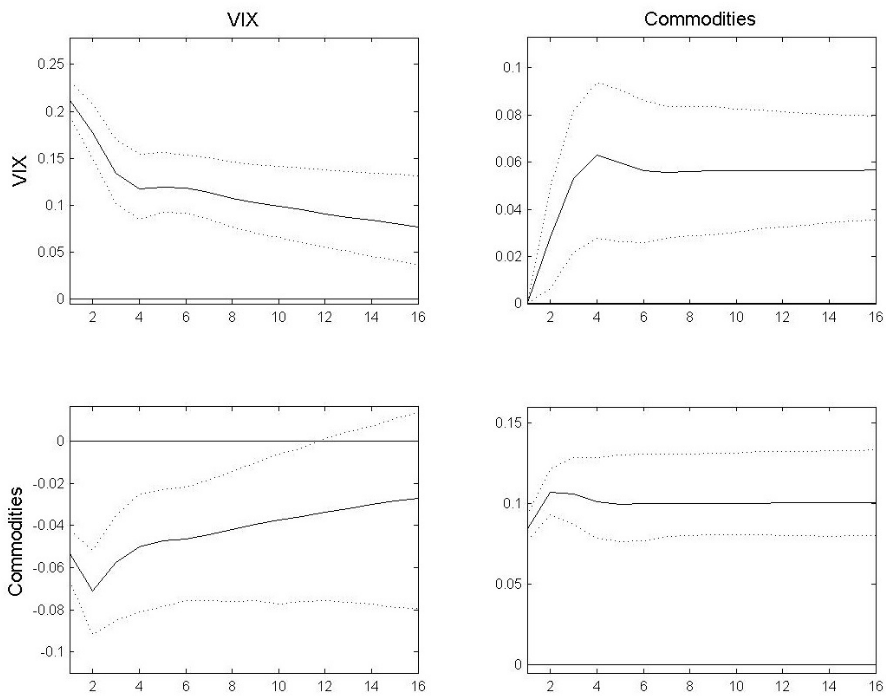

Figure 36 – Response of international variables

D.1.2 Chile

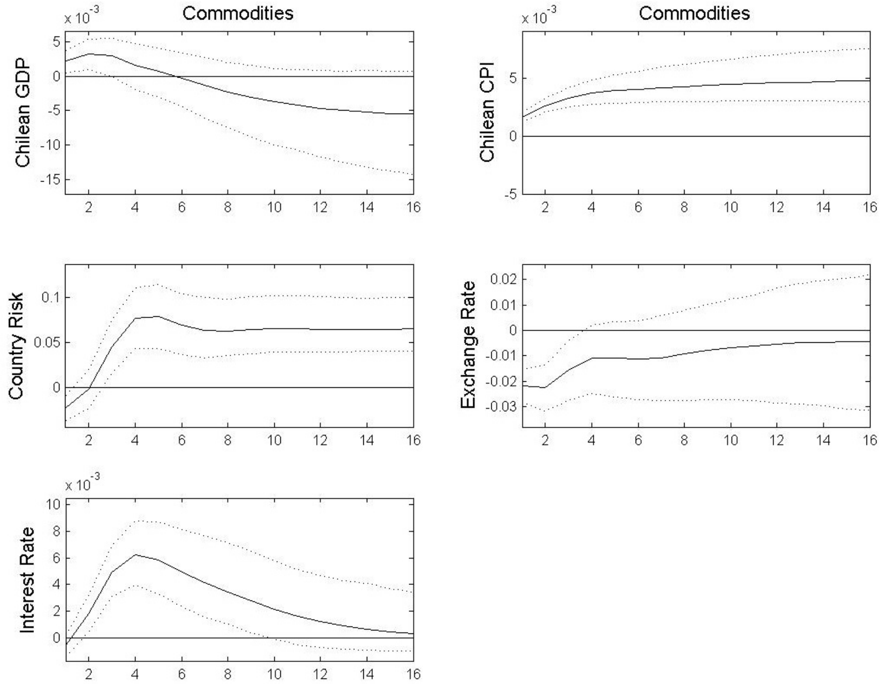

Figure 37 – Response of Chilean variables to a commodity price shock

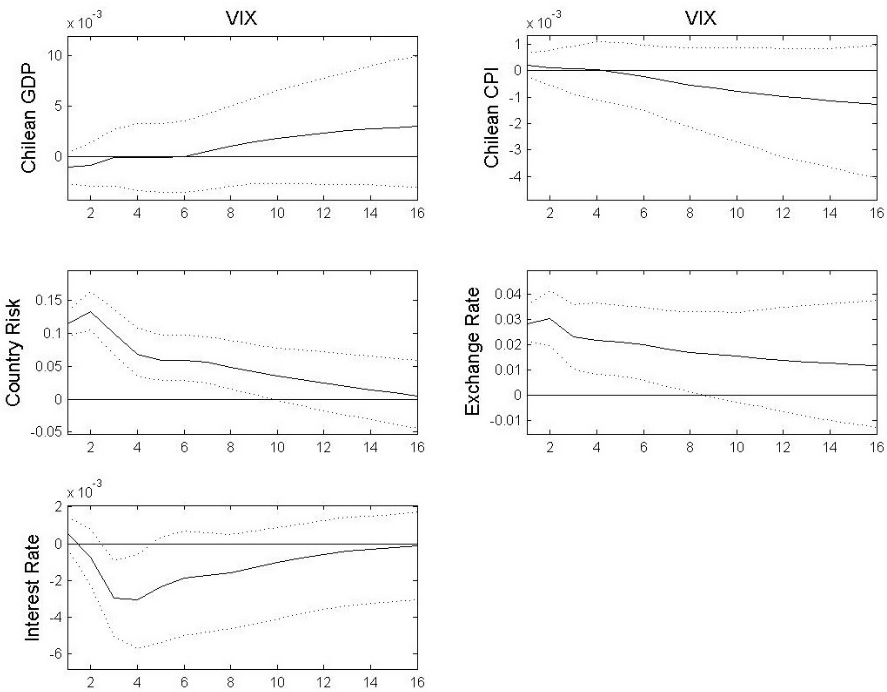

Figure 38 – Response of Chilean variables to a VIX shock

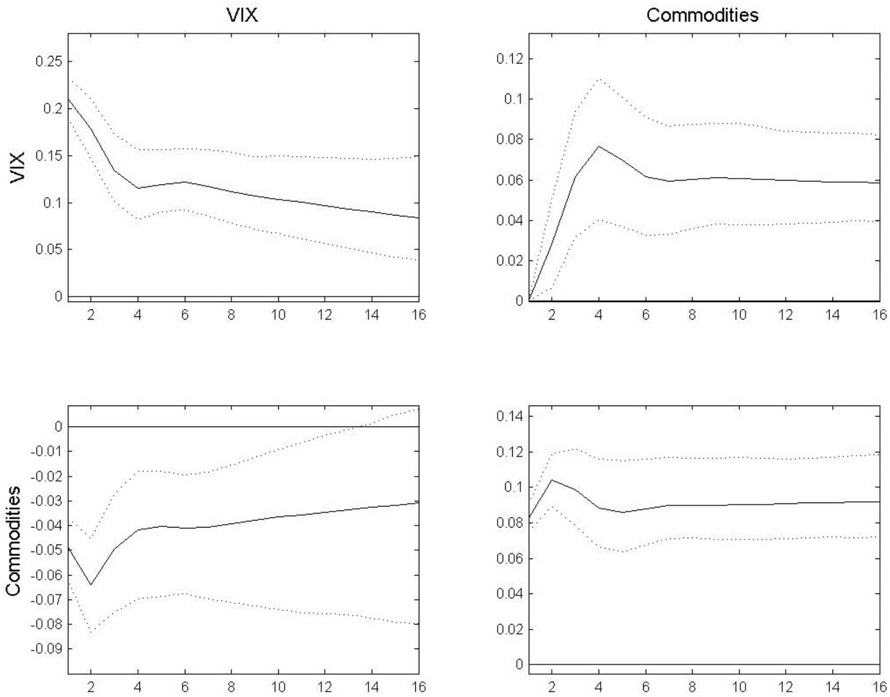

Figure 39 – Response of international variables

D.1.3 Colombia

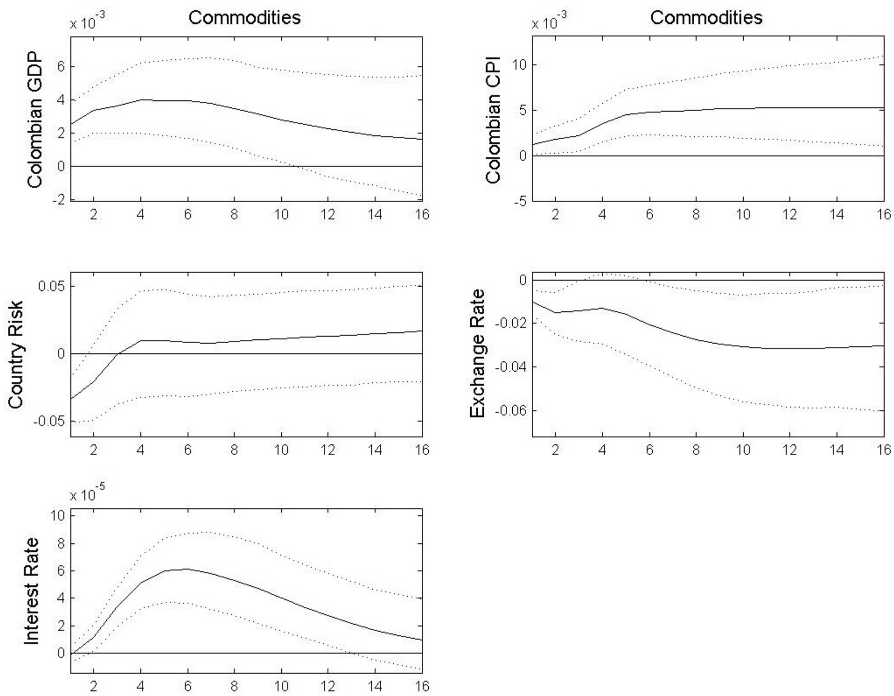

Figure 40 – Response of Colombian variables to a commodity price shock

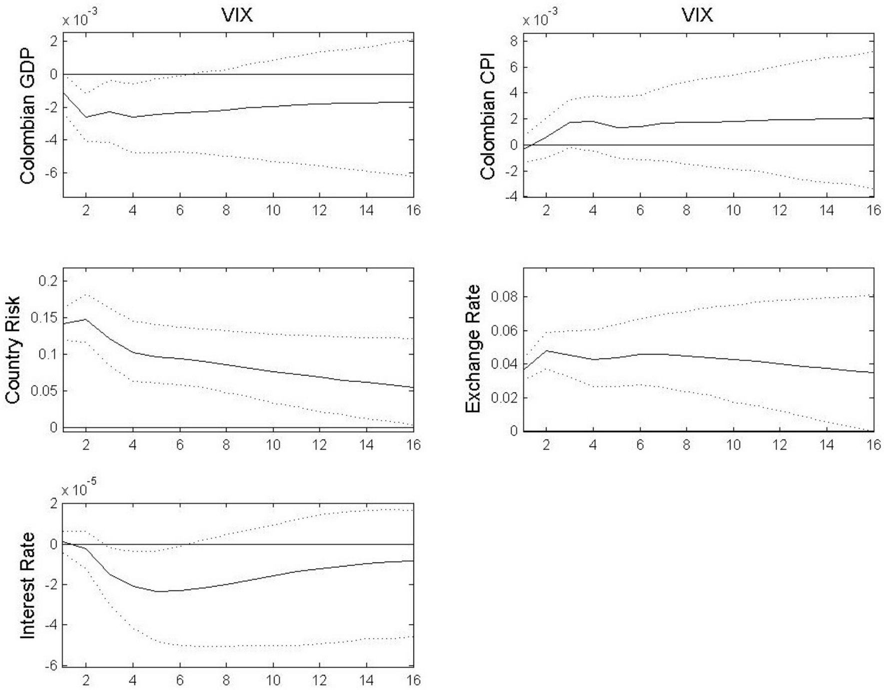

Figure 41 – Response of Colombian variables to a VIX shock

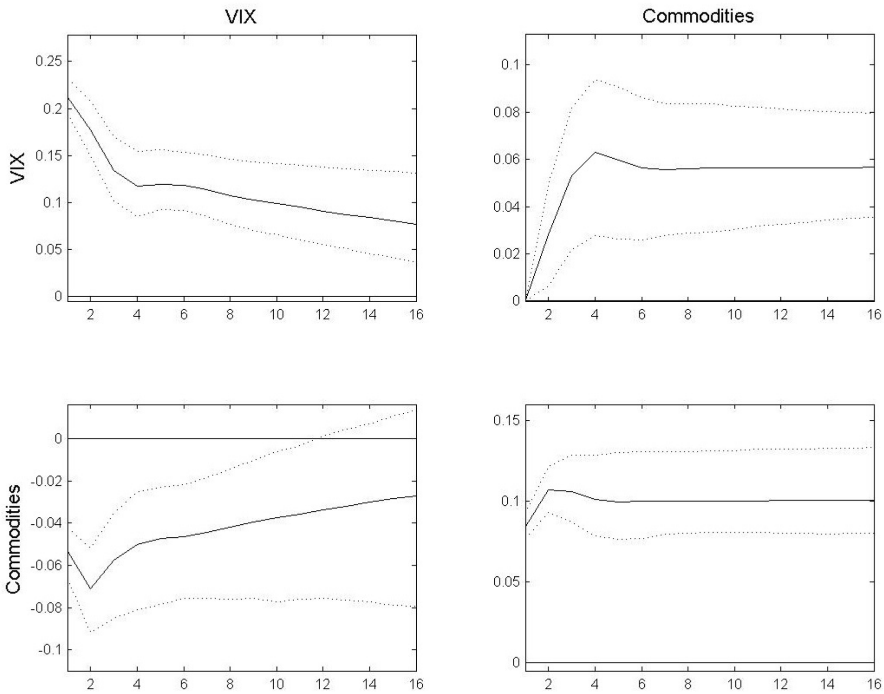

Figure 42 – Response of international variables

D.1.4 Mexico

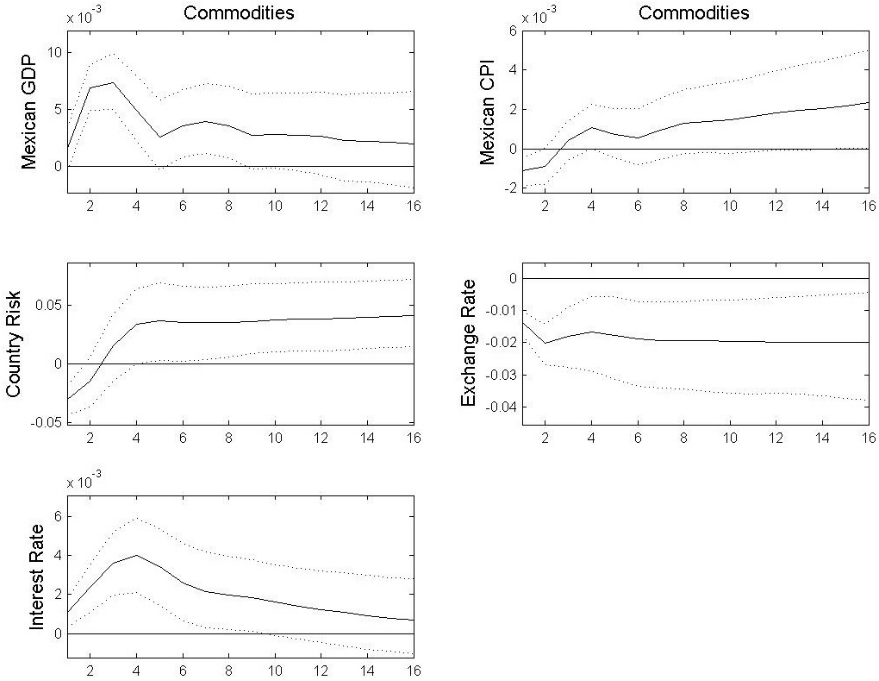

Figure 43 – Response of Mexican variables to a commodity price shock

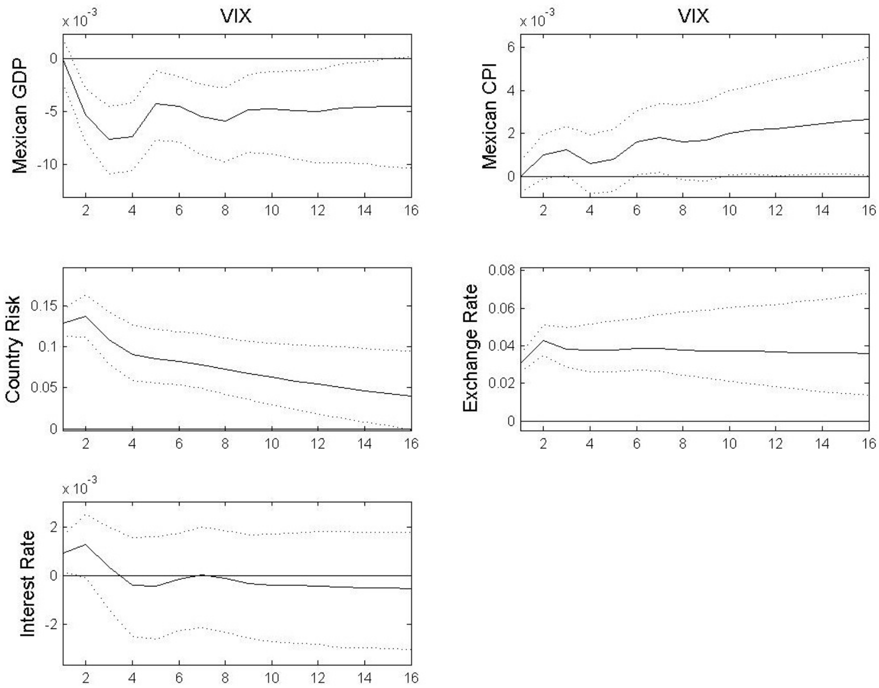

Figure 44 – Response of Mexican variables to a VIX shock

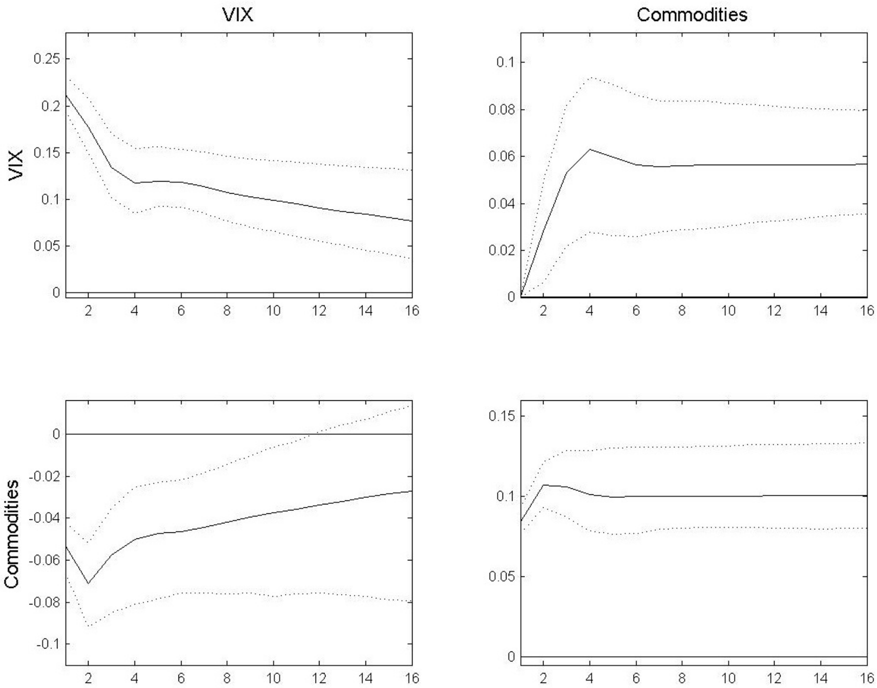

Figure 45 – Response of international variables

D.1.5 Peru

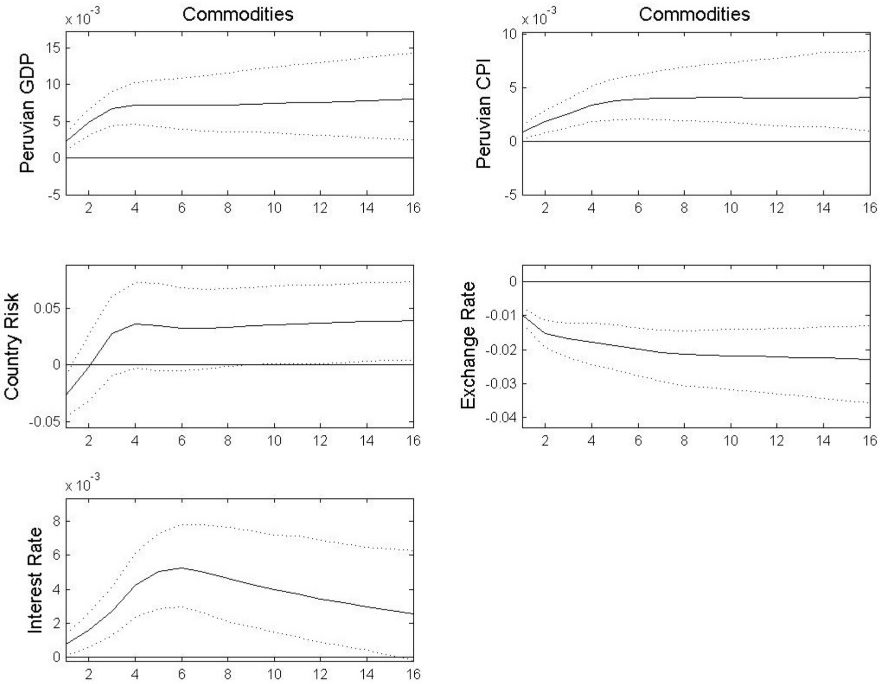

Figure 46 – Response of Peruvian variables to a commodity price shock

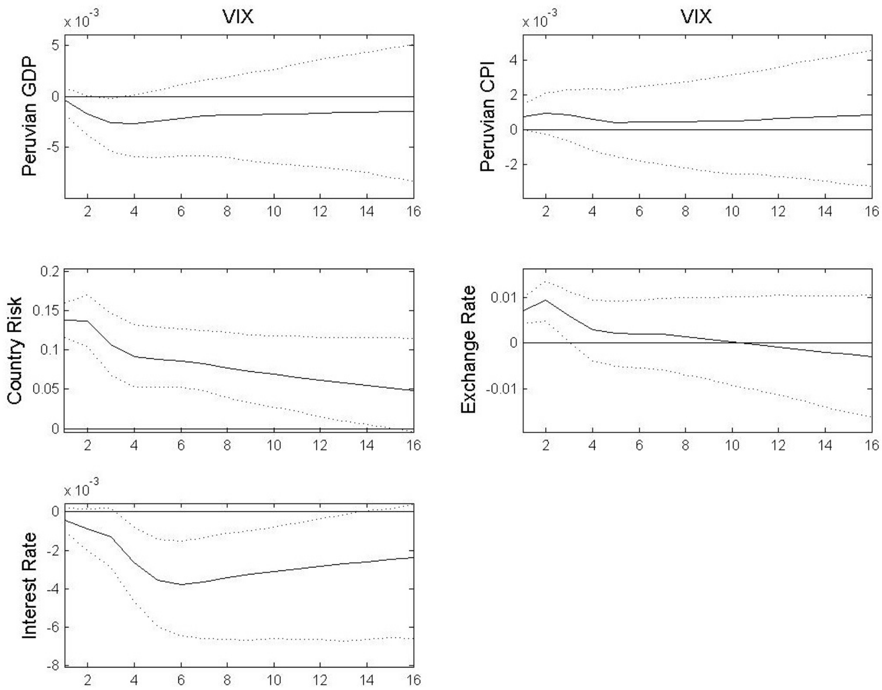

Figure 47 – Response of Peruvian variables to a VIX shock

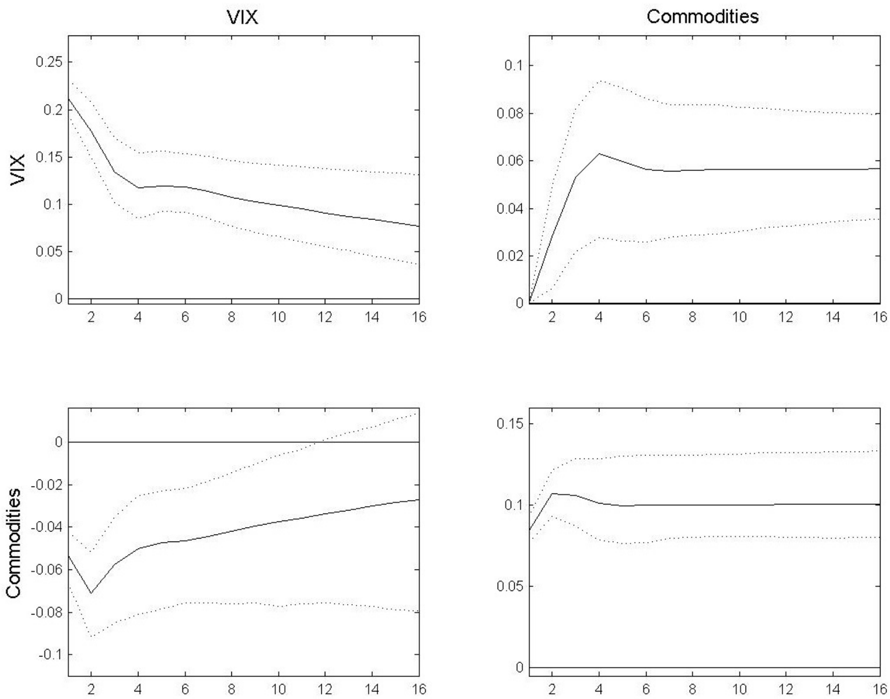

Figure 48 – Response of international variables

D.2 VIX responding to commodities and country risk not blocked

D.2.1 Brazil

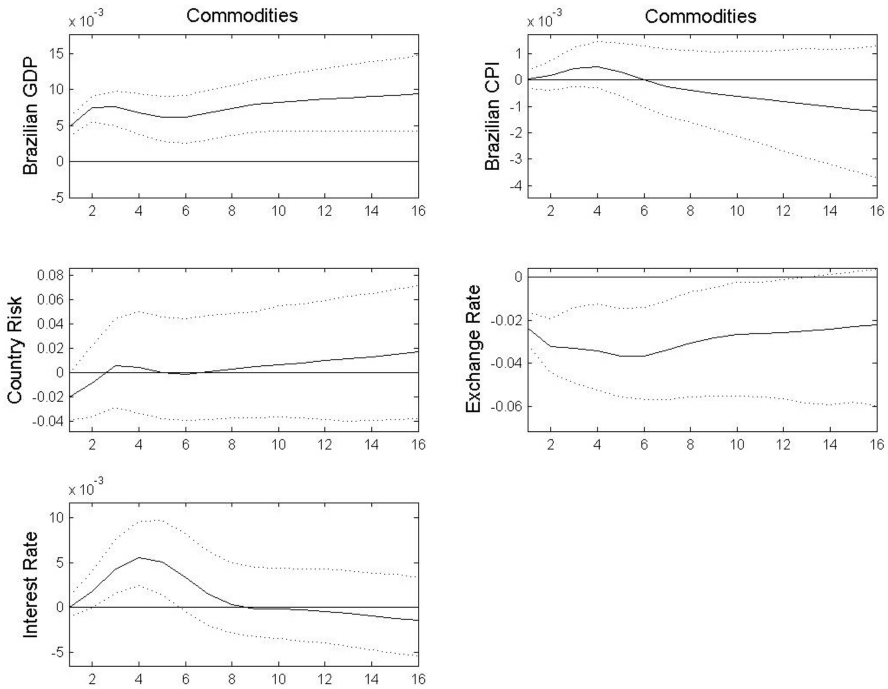

Figure 49 – Response of Brazilian variables to a commodity price shock

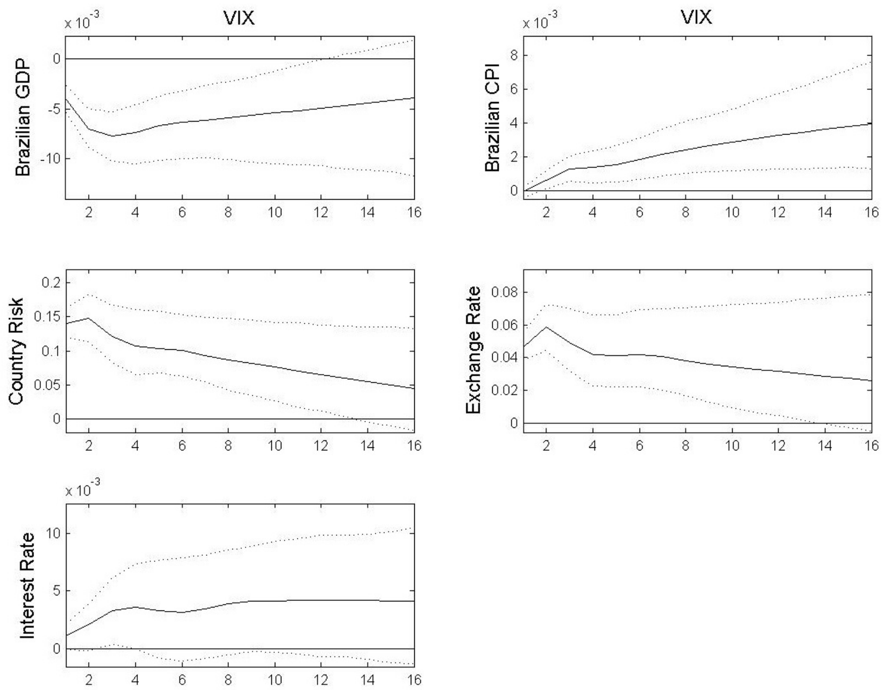

Figure 50 – Response of Brazilian variables to a VIX shock

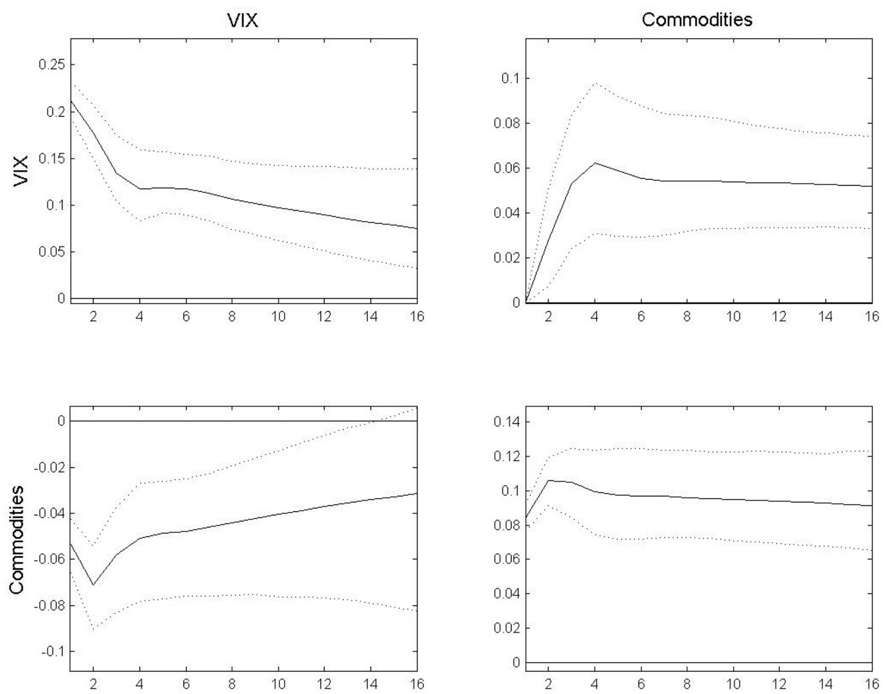

Figure 51 – Response of international variables

D.2.2 Chile

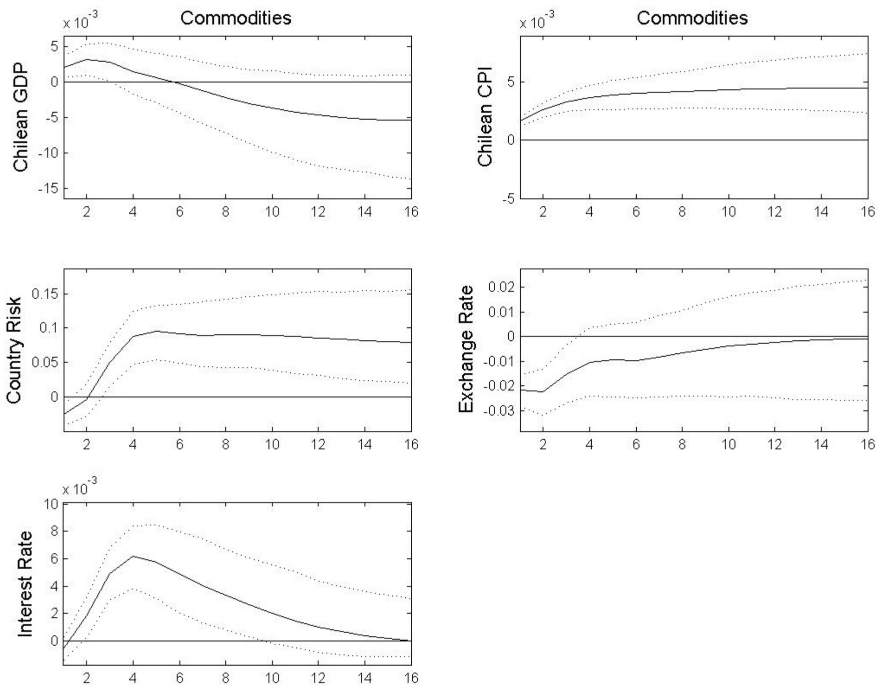

Figure 52 – Response of Chilean variables to a commodity price shock

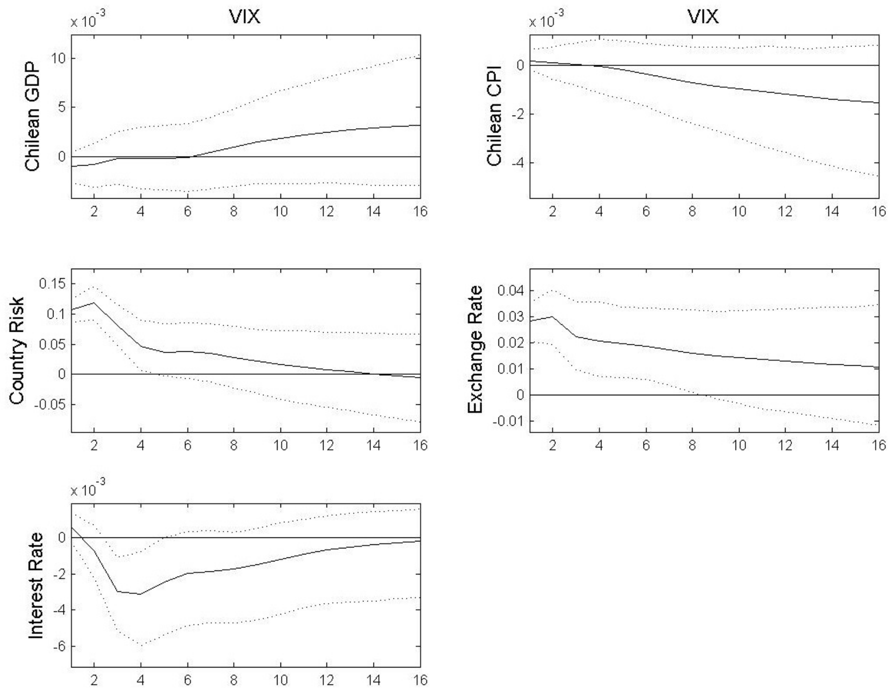

Figure 53 – Response of Chilean variables to a VIX shock

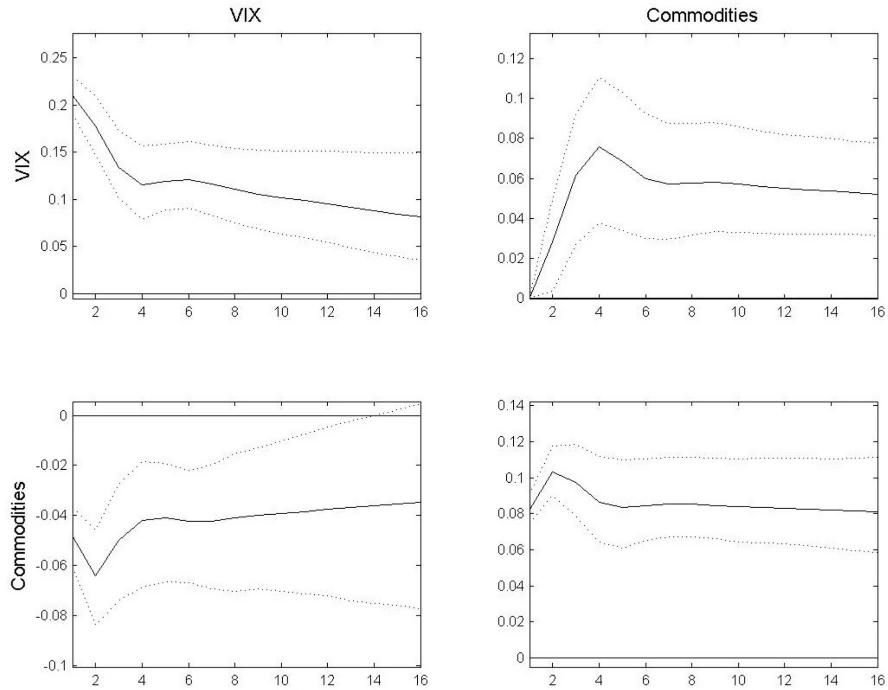

Figure 54 – Response of international variables

D.2.3 Colombia

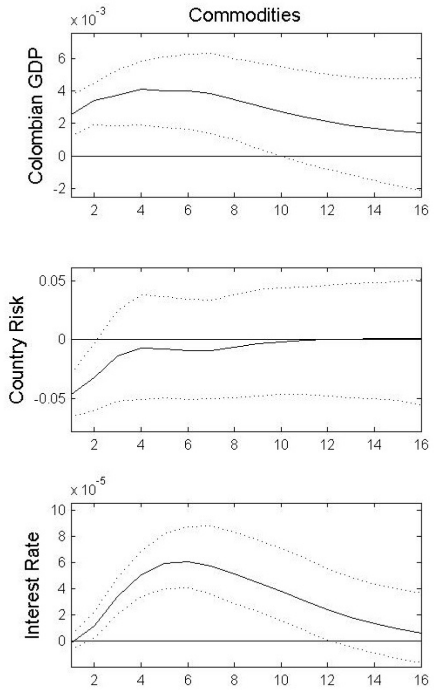

Figure 55 – Response of Colombian variables to a commodity price shock

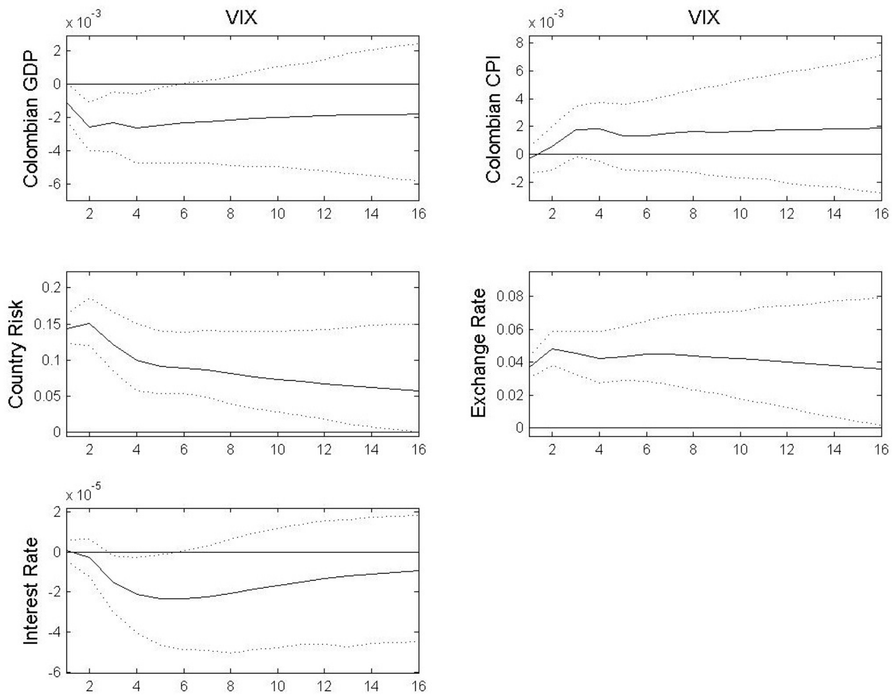

Figure 56 – Response of Colombian variables to a VIX shock

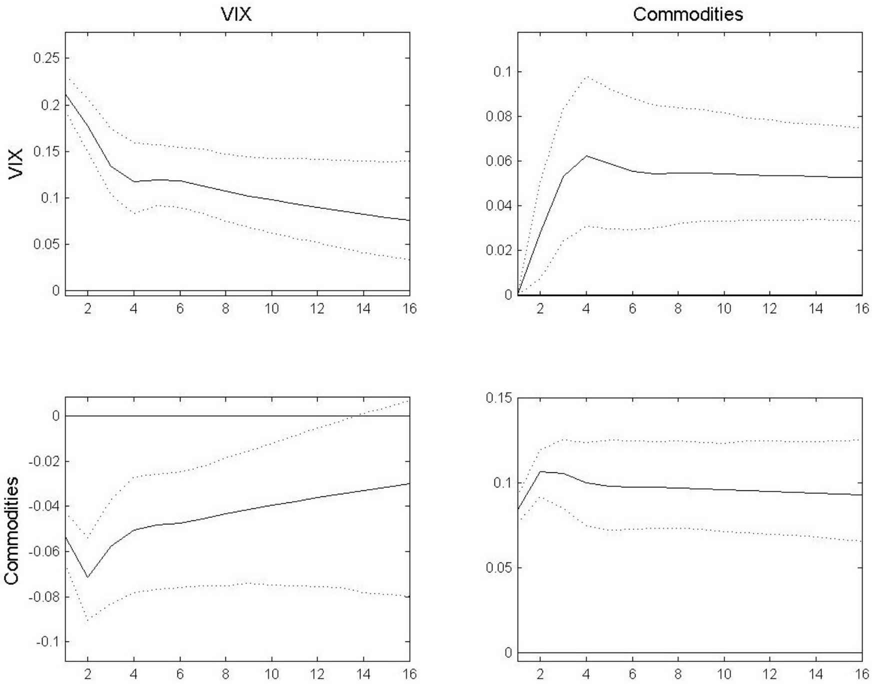

Figure 57 – Response of international variables

D.2.4 Mexico

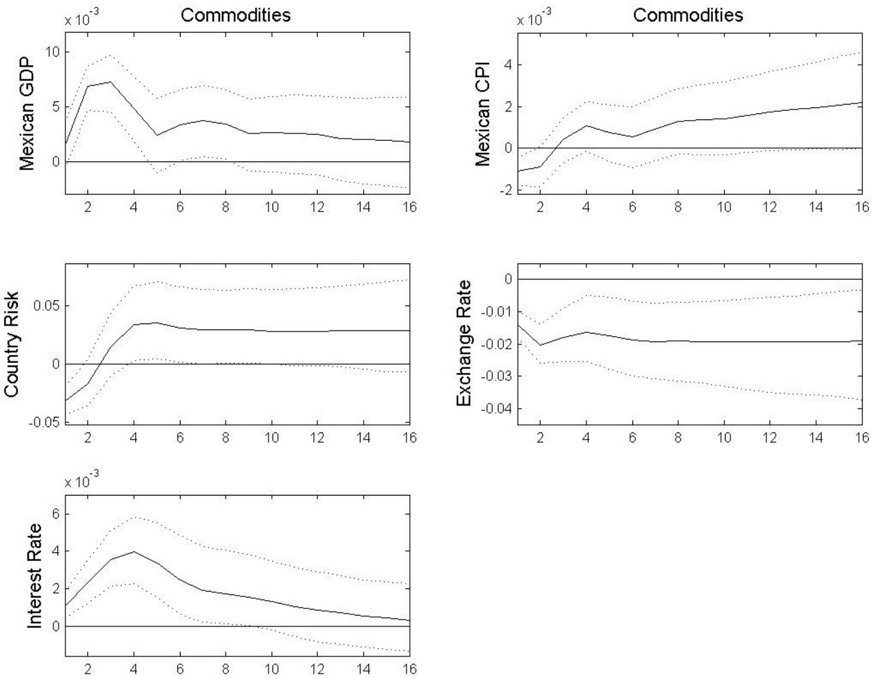

Figure 58 – Response of Mexican variables to a commodity price shock

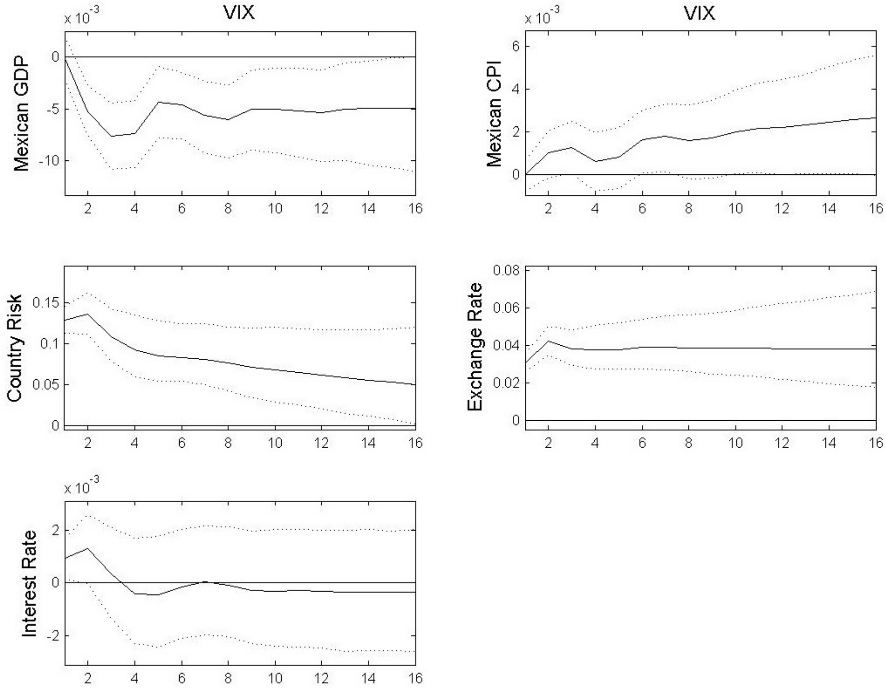

Figure 59 – Response of Mexican variables to a VIX shock

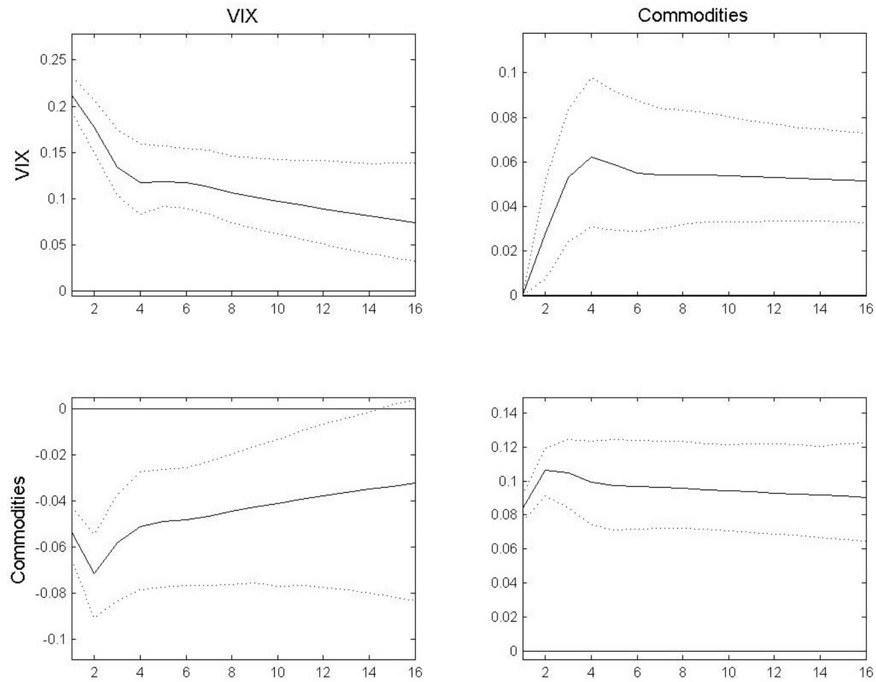

Figure 60 – Response of international variables

D.2.5 Peru

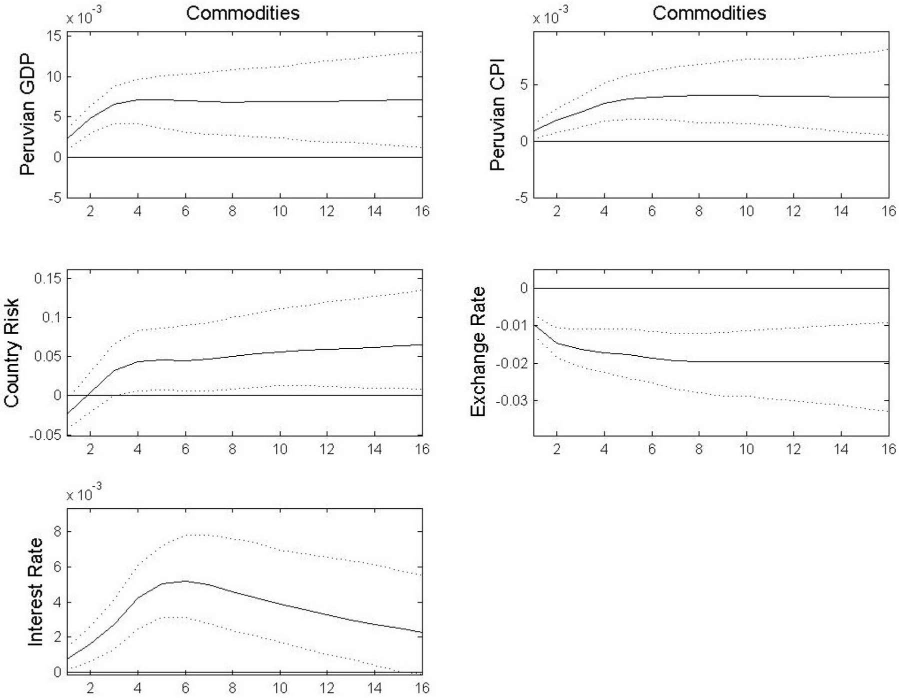

Figure 61 – Response of Peruvian variables to a commodity price shock

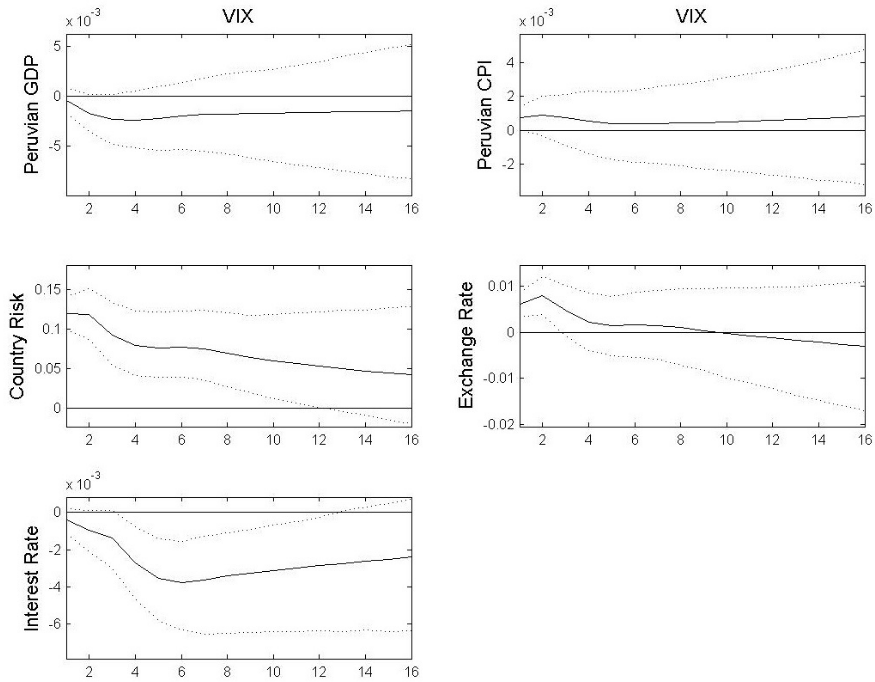

Figure 62 – Response of Peruvian variables to a VIX shock

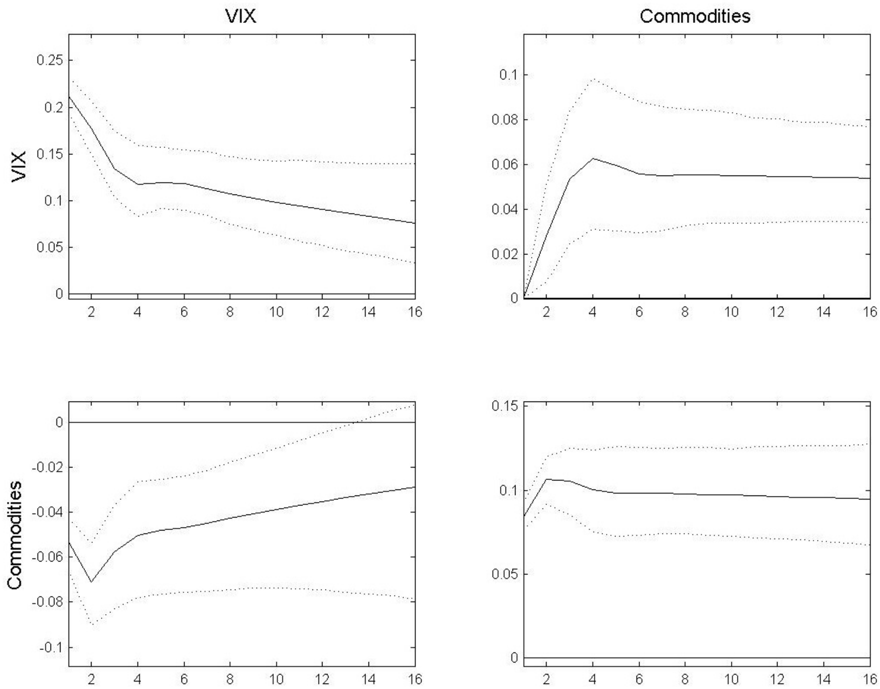

Figure 63 – Response of international variables

D.3 VIX following an AR(4) and country risk not blocked

D.3.1 Brazil

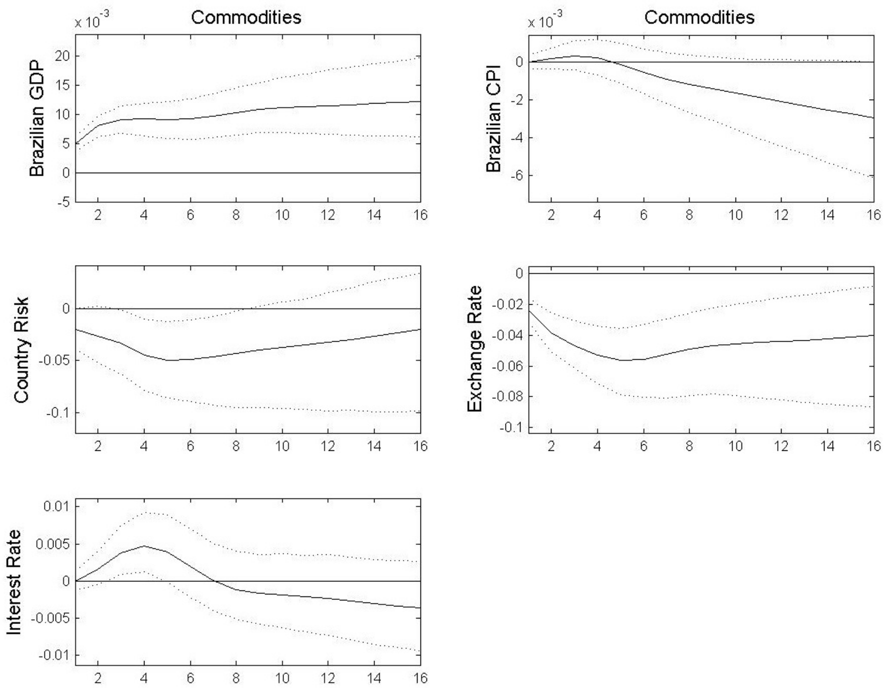

Figure 64 – Response of Brazilian variables to a commodity price shock

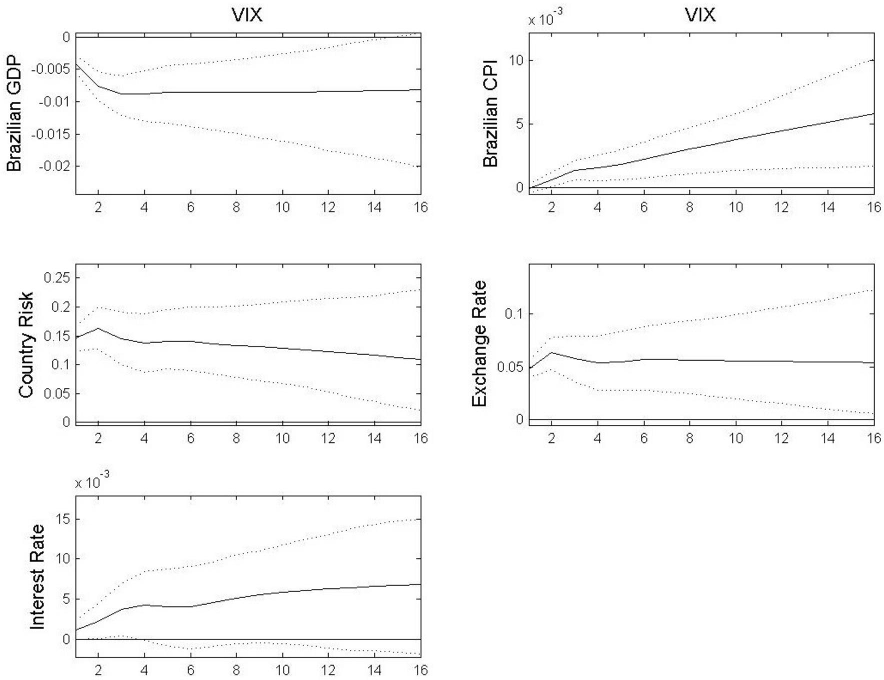

Figure 65 – Response of Brazilian variables to a VIX shock

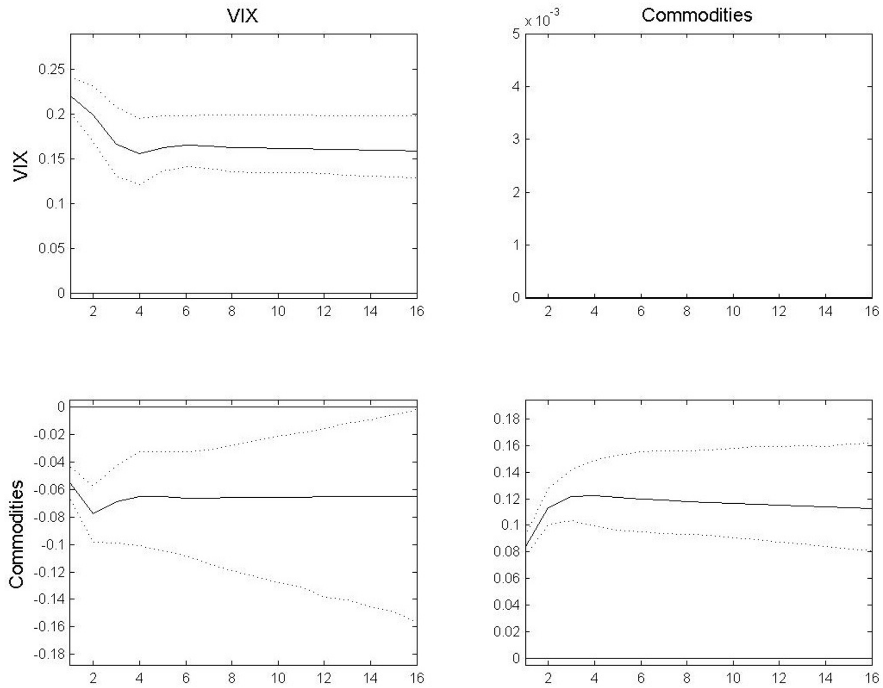

Figure 66 – Response of international variables

D.3.2 Chile

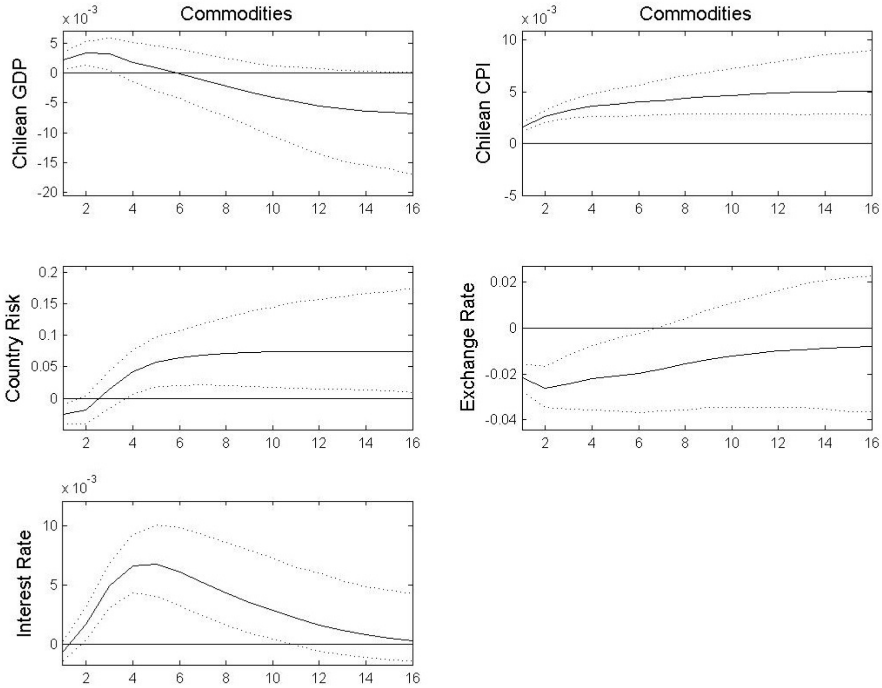

Figure 67 – Response of Chilean variables to a commodity price shock

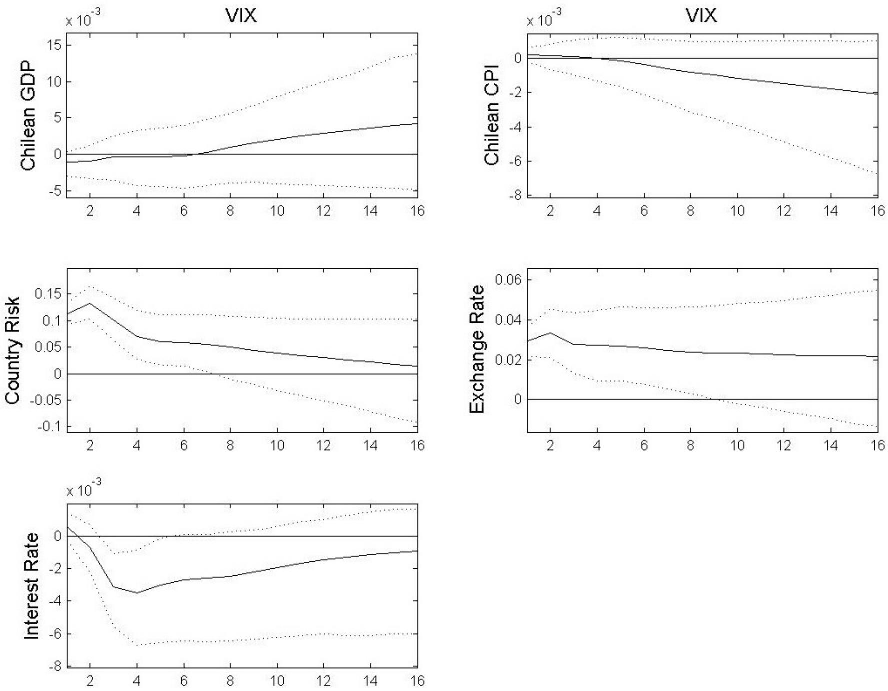

Figure 68 – Response of Chilean variables to a VIX shock

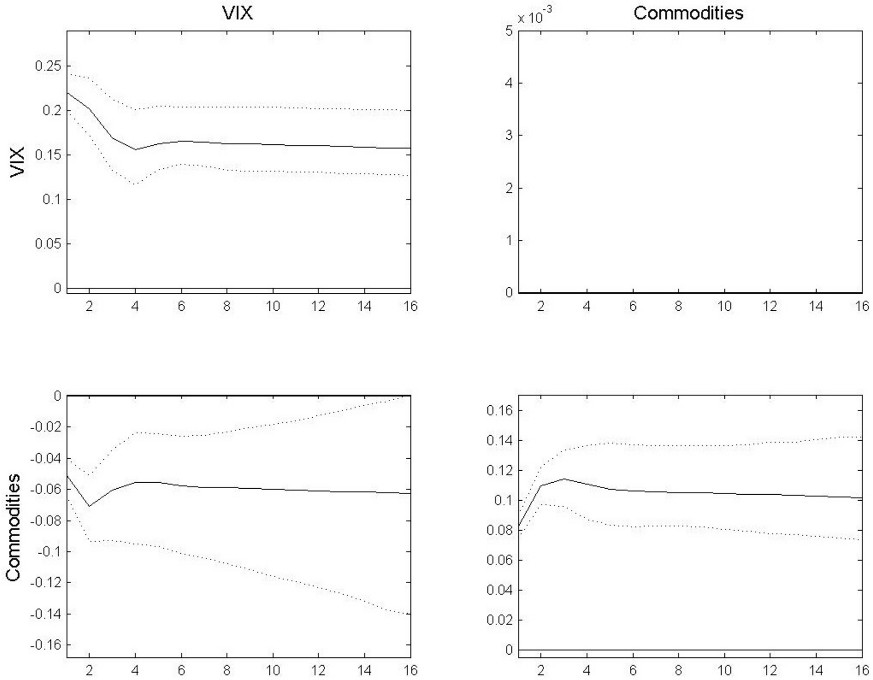

Figure 69 – Response of international variables

D.3.3 Colombia

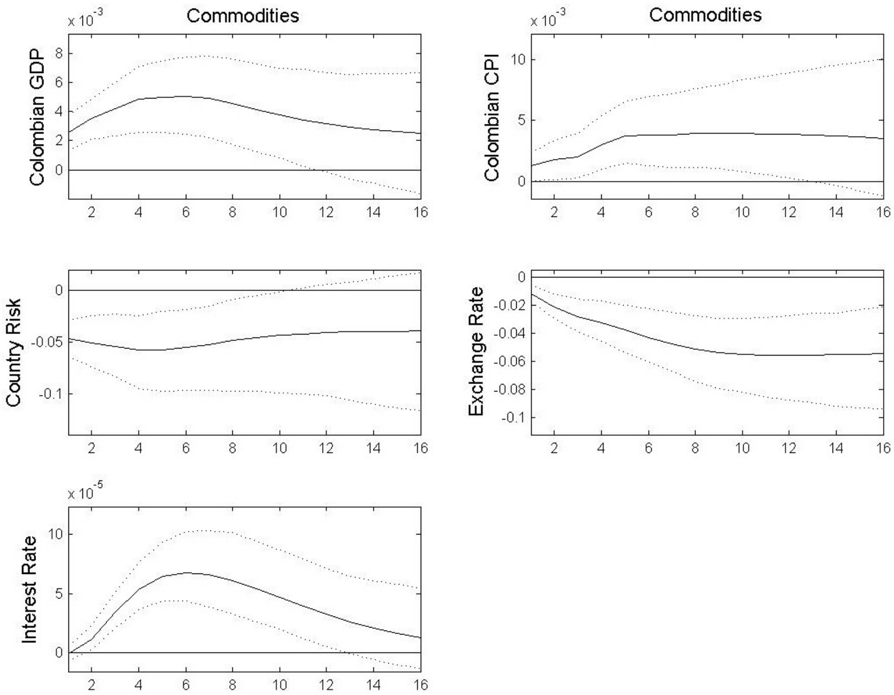

Figure 70 – Response of Colombian variables to a commodity price shock

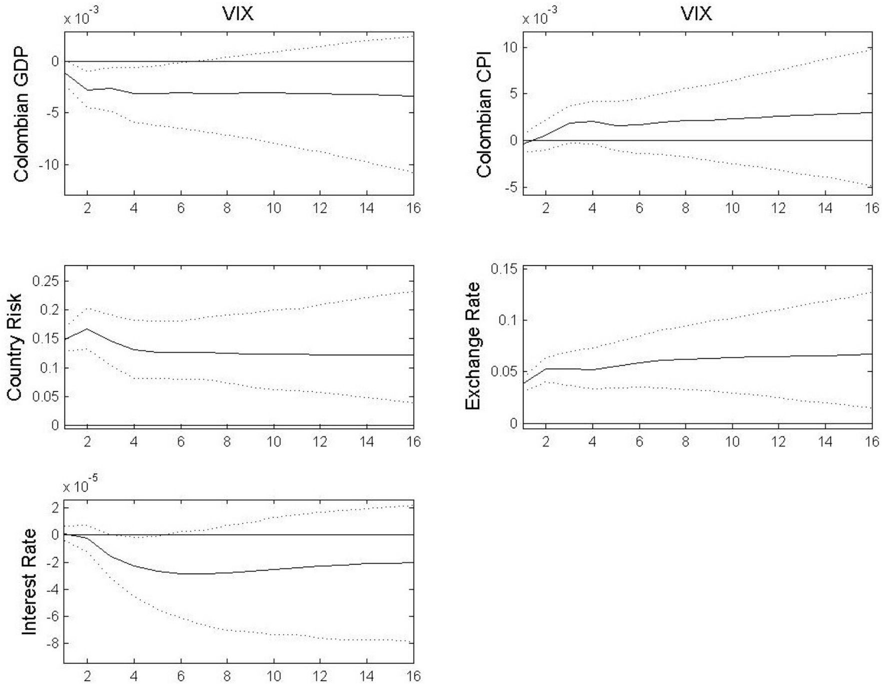

Figure 71 – Response of Colombian variables to a VIX shock

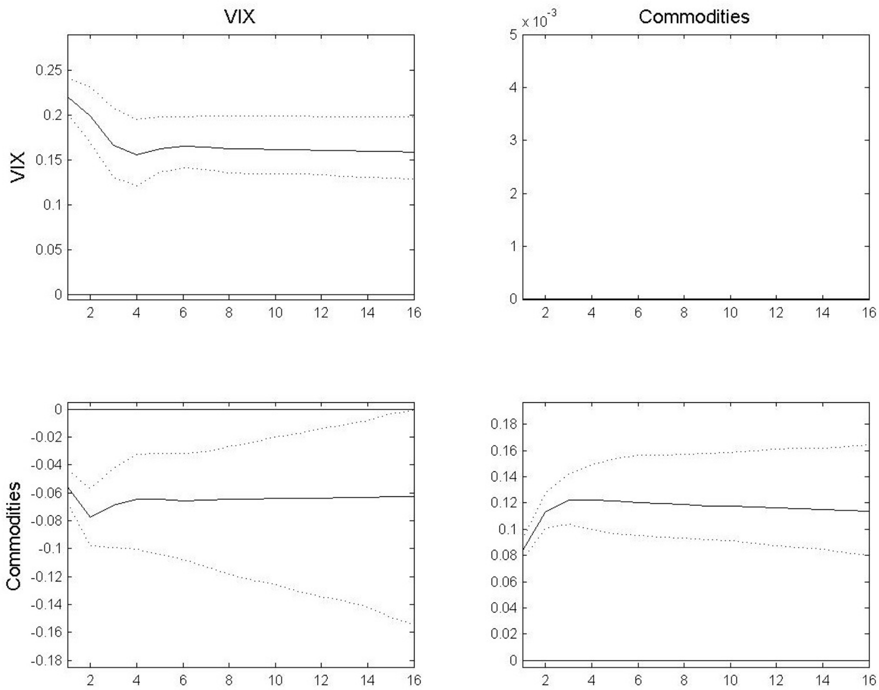

Figure 72 – Response of international variables

D.3.4 Mexico

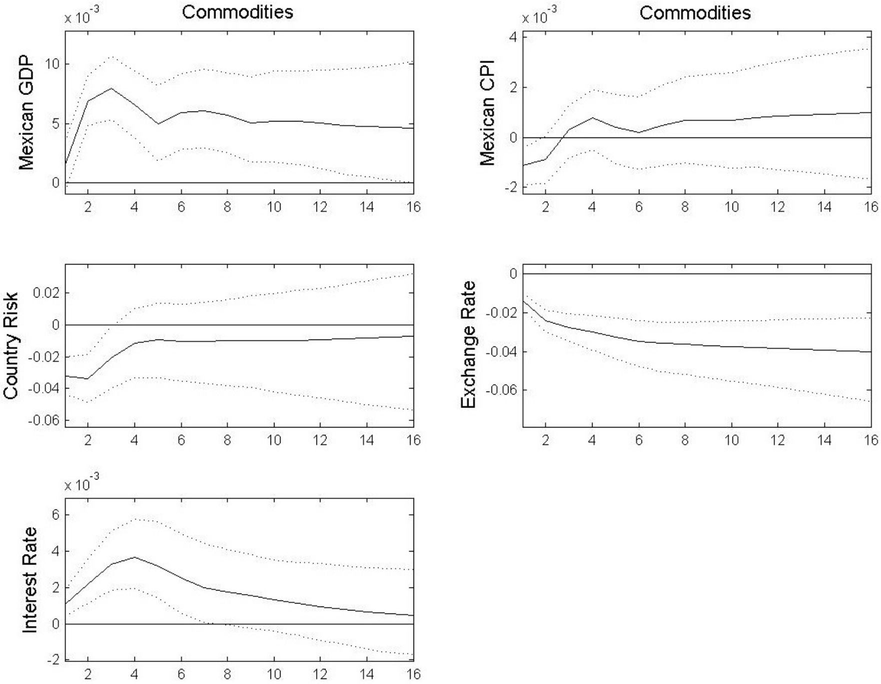

Figure 73 – Response of Mexican variables to a commodity price shock

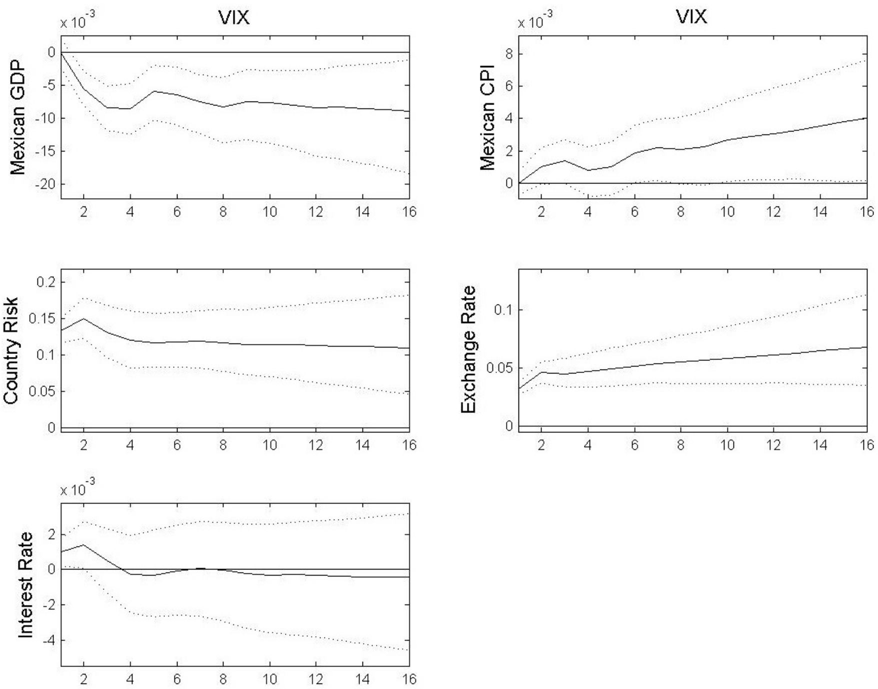

Figure 74 – Response of Mexican variables to a VIX shock

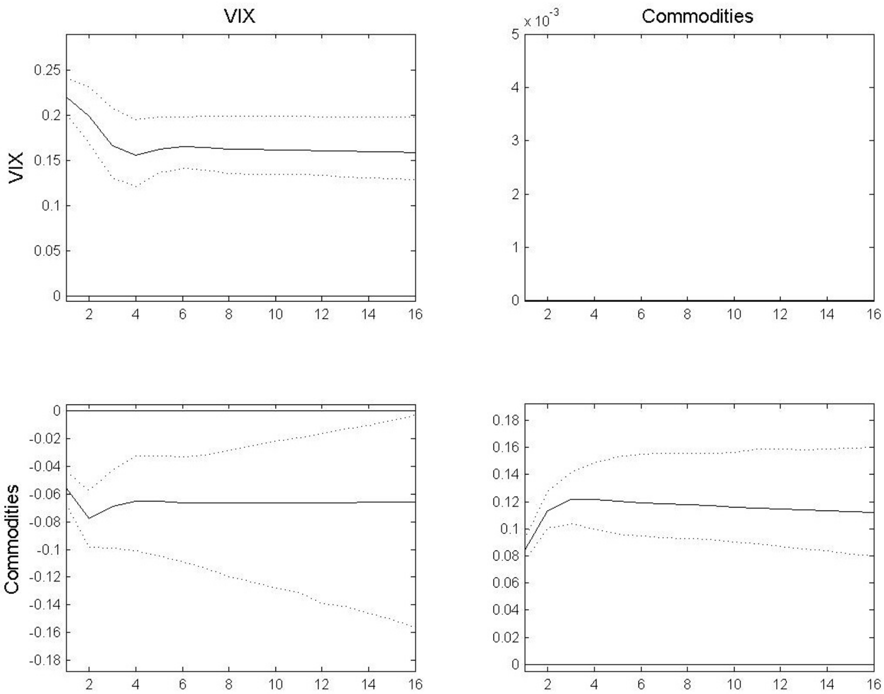

Figure 75 – Response of international variables

D.3.5 Peru

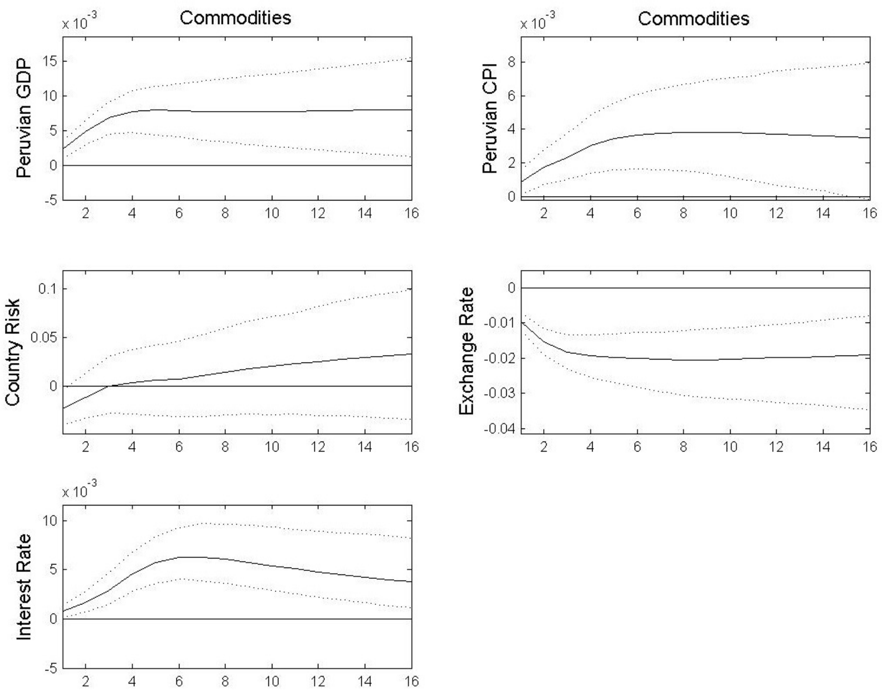

Figure 76 – Response of Peruvian variables to a commodity price shock

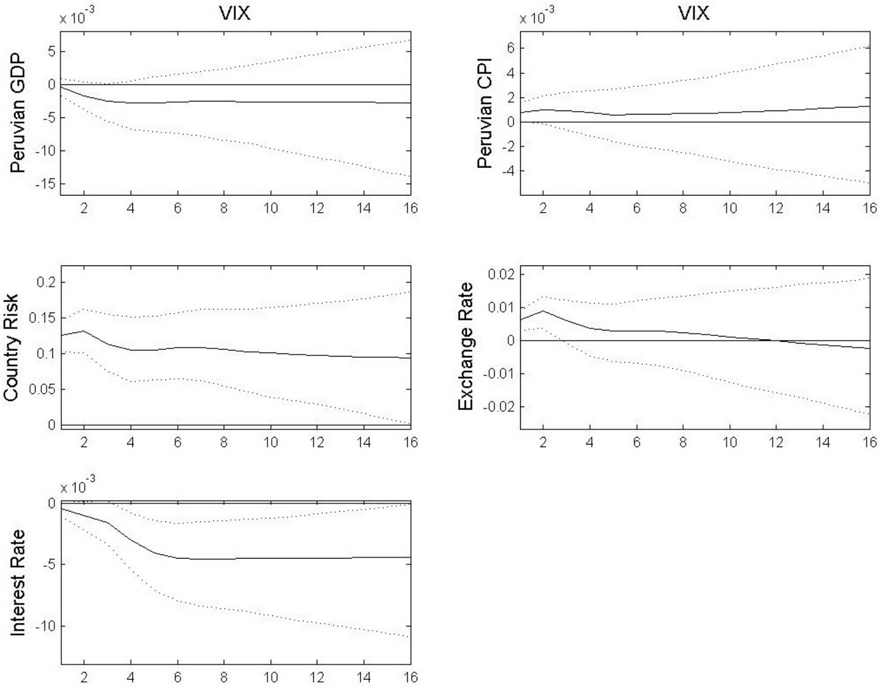

Figure 77 – Response of Peruvian variables to a VIX shock

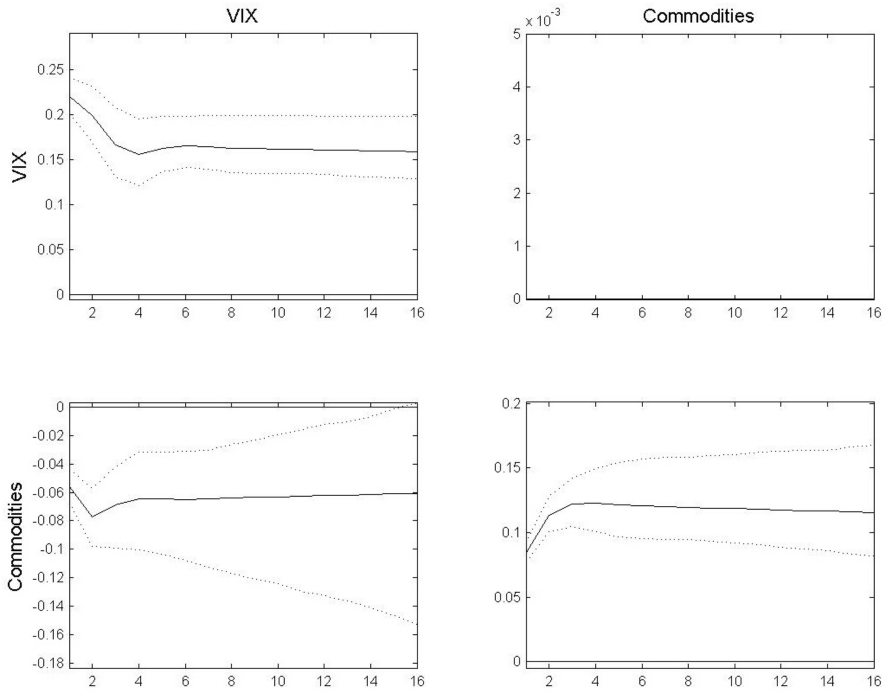

Figure 78 – Response of international variables

APPENDIX E – Data

Table 7 – Data description

Country	Variable	Source	Abbreviation
International	Volatility Index	Federal Reserve of St.Louis	VIX
	All Commodity Prices	International Monetary Fund	PCOM
Brazil	Gross Domestic Product	Banco Central do Brasil	GDP
	Consumer Price Index	Banco Central do Brasil	CPI
	Ratio of Exports and Imports	Banco Central do Brasil	XoM
	J.P. Morgan's Emerging Market Bond Index Global	Banco Central de Chile	CR
	Forex Market Intervention	Banco Central do Brasil	FX
	Nominal Exchange Rate	Banco Central do Brasil	EXR
	SELIC Rate	Banco Central do Brasil	INTR
Chile	Gross Domestic Product	Banco Central de Chile	GDP
	Consumer Price Index	Banco Central de Chile	CPI
	Ratio of Exports and Imports	Banco Central de Chile	XoM
	J.P. Morgan's Emerging Market Bond Index Global	Banco Central de Chile	CR
	International Reserves	Banco Central de Chile	FX
	Nominal Exchange Rate	Banco Central de Chile	EXR
	Monetary Policy Interest Rate	Banco Central de Chile	INTR
Colombia	Gross Domestic Product	Banco de la República	GDP
	Consumer Price Index	Banco de la República	CPI
	Ratio of Exports and Imports	Banco de la República	XoM
	J.P. Morgan's Emerging Market Bond Index Global	Banco Central de Chile	CR
	Forex Market Intervention	Banco de la Repúblic	FX
	Nominal Exchange Rate	Banco de la República	EXR
	Intervention Rate	Banco de la República	INTR
Mexico	Gross Domestic Product	Banco de México	GDP
	Consumer Price Index	Banco de México	CPI
	Ratio of Exports and Imports	Banco de México	XoM
	J.P. Morgan's Emerging Market Bond Index Global	Banco Central de Chile	CR
	International Reserves	Banco de México	FX
	Nominal Exchange Rate	Banco de México	EXR
	Interbank rate	OECD	INTR
Peru	Gross Domestic Product	Banco Central de Reserva del Perú	GDP
	Consumer Price Index	Banco Central de Reserva del Perú	CPI
	Ratio of Exports and Imports	Banco Central de Reserva del Perú	XoM
	J.P. Morgan's Emerging Market Bond Index Global	Banco Central de Chile	CR
	Forex Market Intervention	Banco Central de Reserva del Perú	FX
	Nominal Exchange Rate	Banco Central de Reserva del Perú	EXR
	Reference Rate for Monetary Policy	Banco Central de Reserva del Perú	INTR